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Climate Warming, Water Resources and Geopolitical Conflict: A Study of Nations Dependent on the Nile, Litani and Jordan River Systems

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CLIMATE WARMING, WATER RESOURCES AND GEOPOLITICAL CONFLICT: A STUDY OF NATIONS DEPENDENT ON THE NILE, LITANI AND JORDAN RIVER SYSTEMS

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ABSTRACT

The purposes of this study were to assess the extent to which climate warming is expected to occur in the Middle East, to identify the potential impacts of climate warming on the resources of the Nile, Jordan and Litani River systems and to estimate the extent to which these potential impacts might contribute to political instability in the region. General circulation models of the atmosphere were used to project changes in temperature, precipitation and solar radiation in the region under a scenario of doubling of atmospheric carbon dioxide levels. The models estimate a general warming for the region and a slight decrease in precipitation. This will, in turn, reduce the amount of freshwater available to the region. With water a major source of political instability in the region, the climate warming will have security implications. More important, however, are the rapid population growth and increase in agricultural output. These factors, with climate warming as an associative element, are overwhelming the ability of the resource base to accommodate the changes.

RÉSUMÉ

Cette étude est une analyse de l'impact d'un changement global de climat sur les grands cours d'eau du Moyen-Orient, notamment le Nile, le Jourdain et la rivière Litani et des conséquences d'un tel évènement sur la stabilité politique de la région. À l'aide de modèles sur la circulation de l'atmosphère, l'auteur conclut que le Moyen-Orient subira un réchauffement progressif et une petite diminution des précipitations ce qui entraînera une réduction dans la quantité d'eau potable dans la région. L'auteur constate que cette diminution d'eau potable lorsqu'elle est juxtaposée à une croissance de la population ainsi qu'à des demandes grandissantes sur l'agriculture constitue un problème de sécurité important.

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EXECUTIVE SUMMARY

1. There have been numerous conflicts over water in the Middle East during the past four decades. These have ranged from diversions of water by upstream riparian users that resulted in threats and/or military action by downstream users, to the control and acquisition of water resources through force. The acquisition of the Occupied Territories by Israel after the 1967 War, for example, not only supplemented their fresh water supplies by 50%, but gave Israel almost complete control over the headwaters of the Jordan River, its main source of surface water supplies, as well as control over the West Bank, a vital region for aquifer replenishment. There remains some debate as to the role of water as a catalyst in this conflict, but some Israeli politicians have gone on record as saying that the country will not relinquish their control over the Occupied Territories because of the importance of water. Conflicts have continued, as Israel and Jordan both are in need of additional fresh water supplies. Israel has claimed the Litani River is part of the Jordan River watershed, and one of the reasons for extending the security zone into southern Lebanon, may have been to allow easier access to the Litani.

2. The concern over future water supplies and the possibility of obtaining these supplies through force has some merit, since water has the highest marginal value to the Israeli economy, meaning that an additional unit of water is (far) more valuable to the country than an additional unit of any other resource or output. The implication of this is that Israel would gain the most from engaging in activities that secured them additional water supplies. Jordan is roughly in the same position.

3. Other conflicts are apparent, as well. Turkey's Grand Anatolia Project will cut Syria's share of the Euphrates River by 40% and Iraq's by 80%; the flow of the river was restricted last winter for one month and tensions over the use of the river are high. In 1975, Iraq accused Syria of reducing the Euphrates to an intolerably low level while building the Al-Thawra dam, and rushed troops to the border. While the Euphrates is not considered in this study, the tension is indicative of the type of water related conflicts that exist in the region. On the Nile, Egypt has complained of Israeli water engineers working in Ethiopia and Sudan, designing new irrigation systems which would reduce the flow of the Nile, Egypt's only source of fresh water. The need to increase agricultural output in these countries to meet the demands of a rapidly growing population will result in heightened tensions over the use of water in the future.

4. Climate warming, if it occurs, will have disastrous ecological effects in many regions throughout the world. If a one metre sea level rise occurs (projections are for increases in sea level from 30 - 100 cm.), it will affect over 40% of Egypt's productive capacity and result in salt water intrusion into major water supplies. This study used the output

from three general circulation models of the atmosphere to predict changes in temperature and precipitation under a scenario of doubling of atmospheric carbon dioxide levels.

5. The models project that temperatures will rise an average of five to eight degrees Celsius in the Middle East, and precipitation will decrease by ten to twenty percent, although the three models predicting precipitation change exhibit inconsistent results. One projects a slight increase in precipitation, for example. As a result of these changes, evaporation will increase and the amount of freshwater available to the region will decrease.

6. These changes will pose severe problems for certain countries, such as Jordan and Israel, whose demand already exceeds available supply. The problems will be exacerbated by other economic and demographic changes, however. Countries in the region exhibit some of the highest population growth rates in the world, with population doubling every 25 to 35 years. Coupled with growth in agricultural output, which is very water intensive, and the spatial distribution of the population (converting prime agricultural land to residential uses, which forces agriculture to marginal lands that require more irrigation water more distant from major water sources) the changes will far outstrip the ability of the resource base to accommodate them.

7. Countries like Israel that will require additional water supplies in the near future have four options: 1) to supplement existing supplies through waste water reclamation or desalinization - these processes are very expensive and have not contributed significant amounts to total water supplies (Reuse and efficiency improvements, however, should be incorporated into the region's water management plans); 2) to enter into shared agreements with other states in the region - these have been unsuccessful in the past and with present tensions will likely not be an option in the near future; 3) to restructure their economies away from water intensive processes (agriculture) - with goals of self-sufficiency in food production in most countries, or the major contribution of agriculture to foreign exchange earnings, there will be a natural reluctance to restructure; and 4) to acquire additional water by military means.

8. It appears that climate warming may not exhibit a causal relationship with international security in the Middle East in the near future, but certainly will have an associative connection as the demand for water and food increases and resources become more scarce. It must be considered as one of the interrelated factors, along with population growth and distribution, consumption practices and agricultural output, that together will greatly impact security in the region as they undermine the natural support systems on which society depends.

I. INTRODUCTION[1]

> "...environmental degradation imperils nations' most fundamental aspect of security by undermining the natural support systems on which all of human activity depends."
>
> "Because environmental degradation and pollution respect no human-drawn borders, they jeopardize not only the security of the country in which they occur, but also that of others, near and far."
>
> Renner, 1989

Possibly the greatest environmental threat we will face over the next century is that of global warming, with the potential to disrupt natural and social systems throughout the world. This threat of global warming stems from increasing atmospheric concentration of a group of so-called "greenhouse gases" that trap heat, notably carbon dioxide, methane, nitrous oxide, chloroflourocarbons (CFCs) and water vapour. The primary concern to date has been with carbon dioxide (CO_2), released from the burning of coal and other carbon-based fuels and the burning and decay of the world's forests. Since 1958, when measurements of CO_2 in the atmosphere began, its concentration has increased from 315 to 353 parts per million (ppm). A doubling of CO_2 from pre-industrial levels - expected sometime next century - could result in global temperature increases on the order of 1.5 to 4.5 degrees Celsius (and much greater in the high latitude zones of the northern hemisphere). Concentrations of the other greenhouse gases, currently at much lower concentrations than CO_2, but potentially more potent, are increasing even more rapidly. Methane, which is emitted from wetlands, rice paddies, livestock and from warming permafrost is increasing at the rate of one percent per year (compared to 0.4% per year for CO_2). CFCs have been increasing at five percent per year, although with the Montreal

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[1] Research for this paper was concluded prior to the outbreak of recent hostilities in the Persian Gulf.

Protocol emissions of this gas should decrease over the next two decades. Table 1.1 shows the major greenhouse gases, their sources and their characteristics.

Table 1.1. Major greenhouse gases and their characteristics.

Gas	Atmos. Concen. (ppm)	Annual Increase (%)	Life-span (years)	Relative Green-house Efficiency	Current Contrib. (%)	Principal Source of Gas
Carbon Dioxide (Fossil Fuels)	351.3	0.4		1	57 (44)	Coal, Oil, Nat. Gas,
(Biological)					(13)	Deforest-ation
Chlorofluoro-carbons	.000225	5	75-111	15,000	25	Foams, Coolants
Methane	1.675	1	11	25	12	Wetlands, Rice, Livestock
Nitrous Oxide	0.31	0.2	150	230	6	Fossil Fuels, Deforest.

The theory of a general warming of the world's climate has gained widespread scientific acceptance over the past two decades. Despite the recent reluctance of some western governments to agree to emission reduction targets and the concern over the costs of preventative and adaptive strategies to deal with the impacts of climate warming, there has been worldwide recognition of the need for more detailed studies on the impacts of climate change and on the possible response strategies needed. Using general predictions for precipitation and temperature under a doubling of CO_2 levels in the atmosphere, impact assessments have been undertaken on

agriculture (Smit, 1987; Williams, et al, 1987), lake levels (Cohen, 1988; Morrisette, 1988), tourism (Wall, 1985), regions (Gleick, 1988; U.S. EPA, 1988) and human health (U.S. EPA, 1988) as examples. Most of these studies assume climate warming scenarios provided by large-scale computer models of the atmosphere (and the land and ocean interface), termed general circulation models (or GCMs), which are able to provide temperature and precipitation predictions under conditions of varying levels of CO_2 at roughly a 400km by 400km spatial scale (The Canadian model developed by the Atmospheric Environment Service is more spatially disaggregate, however, operating at a 250km by 250km level). There are now six GCMs in existence, and while most are in general agreement about the amount of warming that will occur, their predictions of precipitation are quite varied.

There are actually two issues to be considered, however, when addressing climate warming and its potential impacts. First, the medium- or long-term average change that is expected to occur. It is this information that the GCMs are able to provide. In many cases, society is able to adapt to gradual environmental change, except where there is a cumulative effect, such as soil erosion in certain Latin American countries. The second, and potentially more important issue, is the short-term variability that might accompany a general warming trend. Hurricanes and droughts would be more severe and more frequent; storm surges along the coasts would be higher and the frequency and duration of periods of abnormally high temperatures would increase. These catastrophic changes, and their impacts, have not been studied in detail. In addition, much of the work on climate change and its impacts to date has been on the change in climate over time; when a CO_2 doubling will occur and what effects a gradual increase would have on physical and natural systems. Of greater concern, however,

may be climatic change over space (Parry, 1986). This may be even more relevant when considering short-term climate variability (and volatility), as the economic loss due to natural hazards is over 20 times greater in developing countries than in the developed world (Burton, et al., 1978).

The potential impacts associated with a warming climate are now in the process of being assessed, as mentioned above. Most of the studies have concentrated on impacts on North American and European regions and systems. Despite the fact that climate warming will be a result of the indulgences of the developed world, some of the major impacts will occur in developing countries. These include: sea-level rises, drought, salt-water intrusion, loss of forests, loss of biological diversity, impacts on human health, and others (cf. U.S. EPA, 1988; Topping (ed.), 1989; Lonergan, 1989). Studies of the impacts on developing nations and on the vulnerability of these countries to environmental stress caused by climate warming are just beginning. Perhaps one of the most disturbing impacts of these changes is that widespread environmental degradation could aggravate international relations, behaviour and security (Gleick, 1989a). In a world experiencing rapid population growth, increased competition for resources and disputes over raw materials can be expected. Additionally, soil erosion and cultivation of marginal lands are further depleting existing resource supplies, leading to economic and social disruption, political unrest, regional and national insecurity, and even international confrontations (Timberlake and Tinker, 1985).

While the reasons for violent confrontations defy simple explanations, it is increasingly acknowledged that, in the complex web of causality of war, environmental factors are often a key feature (Myers, 1986; Russett, 1982; Westing, 1986). Ullman (1983) notes that the root

of most violent conflicts in history was competition for territory and resources, and that the conflict over resources is likely to become more intense as the demand for some essential commodities increases and supplies appear more precarious. All nations require a continuous supply of food, land, water, fuel and raw materials, and the need for assured access to these resources provides a powerful driving force toward conflict. In addition, as long as the concept of national sovereignty remains sacrosanct, a state's resort to arms to retain control of its own natural resources or to protect its access to extraterritorial sources will remain a fully acceptable and frequent means of conflict resolution (Westing, 1988).

This relationship between environment and security is increasingly being acknowledged and studied. The American Academy of Arts and Sciences held a workshop on "Environmental Change and Threats to Security" in March of 1990; the Canadian Institute for International Peace and Security sponsored a conference on "Climate Change, Global Security and International Governance" in April of 1990; and researchers from political science (Homer-Dixon, 1990) to environmental studies (Gleick, 1989a) have addressed this problem in their recent research. The concept of environmental or ecological security is now emerging and, while an established definition does not yet exist, the idea is evolving quite rapidly (Schrijver, 1989). There is now a growing recognition that comprehensive human security has two components - one political and the other environmental. Neither of these components is attainable or sustainable unless the other is satisfied, and the fact that national security relates to such factors as watersheds, croplands, forests, genetic resources and climate is now less often overlooked than it was in the past (Westing, 1989).

Despite this growing interest, however, almost no empirical work has been done to date on the implications of climate warming for national and international security. Although general articles on security-related issues have appeared recently (Gleick, 1989a, b) and the issue of resources, security and conflict has been discussed (Westing, 1986), there has been no detailed regional study of the implications of climate warming for global security, despite the fact that the World Commission on Environment and Development (1987) noted quite succinctly that, "environmental stress is both a cause and an effect of political tension and military conflict." The primary objective of this study, therefore, was to provide a "first-cut" regional analysis of the relationship between climate warming and security, with an emphasis on the Middle East.

The objectives of the study were three-fold. The first was to assess generally the extent to which climate warming is expected to occur in the Middle East. Projections from three general circulation models (GCMs), the Geophysical Fluid Dynamics Lab model (GFDL), the Goddard Institute for Space Studies model (GISS) and the United Kingdom Meteorological Office model (UKMO) will be used. Data on temperature, precipitation and solar radiation have been selected by month for a scenario of doubling carbon dioxide levels in the atmosphere (from pre-industrial levels). The second objective was to identify the potential impacts of climate warming on resources in the Nile, Jordan and Litani River systems in the region. Concentration will be on water availability, withdrawals and demand, but other resource impacts will also be discussed. The final objective was to estimate the extent to which these potential impacts might contribute to political instability in the region.

The study will concentrate on three areas of impacts, with the first of these being the most important for the purposes of this study:

1. Water Resources
2. Food Resources
3. Human Migration (Environmental Refugees)

Figure 1.1 presents a conceptual framework for the study listing variables that may be affected by climate change or which may contribute in other major ways to political instability in the future. As will be illustrated below, it is difficult to isolate one factor and establish a causal relationship between climate change and instability. Determining whether climate warming has a causative relationship to international security or simply an associative connection is one of the secondary objectives of the study. As mentioned above, most work to date on the issue has been primarily an intuitive reaction to the problem or an attempt to develop theoretical frameworks for incorporating environmental factors in conflict analysis. The goal of this study was to identify the potential role of climate warming in geopolitical stability through its impact on resource availability, a downward pull on economic performance, a factor in social dislocations, or a combination of the three. It concentrates on a region where political instability and the potential for conflict is more the norm than the exception; the Middle East.

The potential for increased insecurity associated with environmental disruption and the need for a coordinated response makes the Middle East one of the most important, and most challenging areas of the world for study. The region is already experiencing intense conflict, as different religions, sects, and people vie for control of territory and national destiny in a hostile natural environment blessed with some of the globe's most valuable resources (Calleigh, 1983). The rivalries between and within the Middle Eastern states are among the oldest in the world, and yet the same nations hold some of the most sophisticated armaments of modern

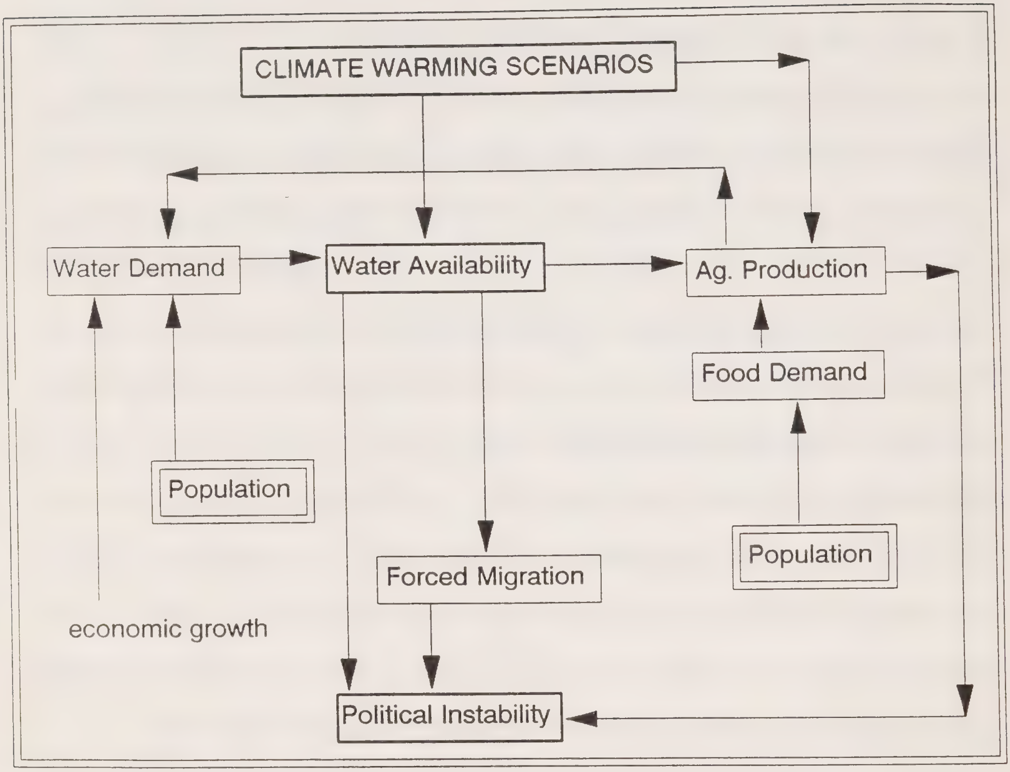

Figure 1.1. Conceptual framework for the study on climate change and security in the Middle East.

society (Heathcote, 1983). In general, the region's governments are facing the many difficulties commonly experienced during industrialization, and at the same time they must contend with disruptive population growth, a lack of some essential resources, and the problems associated with development in an arid region.

Perhaps the most pressing issue nations in the Middle East are facing is a scarcity of water. It is increasingly acknowledged that water, not oil, is the region's most precious resource, and water is now recognized as the fundamental political weapon in the region (Anderson, 1988). All of the governments in the region give high priority to water policies, but the rainfall is generally very low and unreliable, and rapid population growth in the region is exerting great pressure on existing supplies. Accompanying the lack of water and the generally arid conditions is a failure of agriculture to meet increasing demand (Beaumont et. al., 1988). In the early 1980s, the countries of the Middle East formed the world's most rapidly growing food deficit area (Weinbaum, 1982), and this trend has continued throughout the decade. These problems are extremely destabilizing, leading to disruptive population movements both within national borders and between countries, further increasing the already dangerous tensions in the area. For decades, the importance of resources in the Middle East has been clear, and Thompson (1978) cautions that in our pre-occupation with the more immediate and conspicuous politics of energy we should not lose sight of more elementary but no less explosive sources of future conflict, such as water.

Water Resources

Water demand and supply are very vulnerable to changes in climate. About 50 countries have 75% or more of their total area falling within international river basins (UN, 1978) and 40% of the global population lives in multinational river basins (Widstrand, 1980). It has already been noted that the continued decline in water levels in the Nile River could threaten the political stability of the region; the next war in the Middle East, according to Egyptian officials, may very well be over water (Hecht and Doos, 1988). The potential loss in water for consumptive uses due to drought or salt water intrusion as a result of climate warming make this a key sector for study. Regions most exposed to future water competition are: a) Middle Eastern rivers, in particular the Jordan and Euphrates Rivers; b) African rivers, notably the Nile, Zambezi, Niger Senegal and the Medjerda Rivers; and c) South Asian rivers, in particular the Ganges, Brahmaputra and the Mekong Rivers (Falkenmark, 1986). For the purposes of this study, three river basins will be studied; the Jordan, the Litani and the Nile. The Jordan and Litani Rivers are scenes of conflicts in water flow and diversion interests among Israel, Jordan, Syria and Lebanon. The Nile River is also the site of water flow and diversion conflicts, as well as problems of siltation and flooding, and affects Egypt, Ethiopia and Sudan.

Food Resources

Threats to food supplies and agricultural systems have been cause for past frictions and tensions within and between nations, where threats include trade embargoes, environmental degradation from erosion or competition among land uses (Wallensteen, 1986). Although it is

difficult to determine the precise impacts that climate warming will have on agricultural yields, the political significance of food has been well documented, and increased environmental stress will exacerbate the problem. Two primary aspects of food and security are apparent: a) the use of food as a political weapon (including food embargoes); and b) the role of food in conflict formation (caused by problems with food production, food distribution or food trade). Much of the vulnerability of regions to food resource problems results from their level of industrialization and the diversification of their economies (Schneider, 1983), and hence, the developing world is at substantial risk. Major problems could occur (and, quite obviously already have) as a result of increased desertification in the Sahel. According to the United Nations, 35% of the world's land surface is threatened by desertification, affecting almost 20% of the global population. Climate warming would be another environmental stress in an already dire situation, and the Ethiopian famine crisis is one notable example of how a situation might evolve. The potential for climate warming to contribute to increased desertification and degradation of the food resource in the region is a major concern. Equally as important would be the additional demands on water for irrigation purposes under a warmer, drier climate.

Human Migration (Environmental Refugees)

The mass movement of human populations may very well be the result of some of the impacts associated with global warming. Jacobson (1988) notes three types of environmental refugees: 1) those temporarily displaced due to local disruption; 2) those who migrate because environmental degradation has undermined their livelihood or poses unacceptable risks to health; and 3) those who resettle because land degradation has resulted in desertification or because of

other permanent changes in habitat. The impacts of climate warming may well add to the numbers of the last group, causing some developed countries to pressure the developing world for policies to deal with the environmental refugee problem. The environmental refugee problem has already become a sensitive international issue, and it is likely that increased desertification and degradation of food resources in the Sahel will contribute significantly to the refugee problem. While it is more difficult than the first two items to study, since it is a second round impact, the potential for causing political conflict warrants inclusion in this work.

Outline of the Study

The material presented below is structured into three sections. The first contains a brief overview of climate warming and then presents projections for temperature and precipitation under a doubling of carbon dioxide levels for the Middle East. For the purposes of the study, the region is divided into: 1) the Jordan-Litani region; 2) the lower Nile; and 3) the upper Nile. No attempt will be made to duplicate the material on global warming that has been extensively covered elsewhere. The next section presents a short description of the river systems studied, followed by an assessment of impacts corresponding to the three areas of impacts listed above. The last section discusses the climate-resources-security linkage, commenting first on past conflicts over resources and following with the potential for climate-induced conflict to arise.

II. CLIMATE WARMING AND THE MIDDLE EAST

A. Introduction

It should be noted at the outset that anthropogenic emissions of certain gases, most notably CO_2, methane, CFCs, nitrous oxides and water vapour, all contribute to a general process known as the "greenhouse effect." The term greenhouse gas has been applied to atmospheric gases that are relatively transparent to incoming short wave solar radiation but which absorb the long wave radiation from the surface of the earth and re-emit it downward, warming the surface of the earth and the lower atmosphere. The emissions of these gases is increasing at a constant rate, as indicated in Table 1.1. What should be recognized is that the major sources of greenhouse gas emissions are known and that the role of these gases in influencing climate is well understood and accepted. The controversy surrounding the general global warming which may accompany the rapid increase in greenhouse gas emissions is based on our inability to accurately predict the effect these gases will have on climate in the presence of other atmospheric processes. Projected climate variables, such as temperature, precipitation and solar radiation have been projected under different concentrations of greenhouse gases in the atmosphere through the use of large, numerical simulation models (ie., GCMs). While these are quite sophisticated, they are not able to capture all of the complexities of our climate system. In many cases, we simply do not know what the buffering capacity of clouds will be or the effect the oceans will have on mitigating the expected global warming. Recent articles in the popular media (e.g., the New York Times and Forbes magazine; the latter of which had a cover story in the December 25, 1989 issue entitled, "The Global Warming Panic: A Classic Case

of Overreaction") have concentrated on the inability of these models to represent accurately the complexities of our climate system. Many of these articles have been stimulated by the concern on the part of some western governments of the cost of imposing CO_2 emission standards unilaterally. These have been estimated to be as high as 3% of GNP for the U.S. under a scenario of 20% reduction in 1988 levels of CO_2 emissions by the year 2010. In an environmental ministers conference held in Noordwijk, the Netherlands, in October, 1989, three countries voted against setting CO_2 emission quotas; the U.S., Japan and the USSR, for three different reasons. The U.S. was concerned about the potential cost of emission controls and based their refusal on the lack of knowledge as to the extent of global warming; Japan has achieved tremendous energy efficiency gains over the past 15 years, now producing one dollar of GDP with only 35% of the energy that Canada uses, and felt that past reductions in CO_2 output should be taken into account; and Russia is convinced that any warming trend will be economically beneficial to their agricultural sector and sees no reason to reduce or inhibit emissions.

The following, points, however, are accepted. First, anthropogenic releases of greenhouse gases are increasing at a constant rate. Second, these gases, in the absence of other changes, will result in a general global warming. Third, there will be regional variation in the amount of warming (and changes in other climate parameters, such as precipitation). And fourth, the consequences of such warming could be very great, depending on the ability of systems to adapt to these potential changes. What is not accepted is how other earth systems, such as the oceans and clouds, will act to alter the expected warming or how natural variations in climate may mitigate many of the expected changes.

B. General Circulation Models

Most of the predictions of climate warming discussed in both the scientific and popular literature are the result of output from three-dimensional, numerical models of the earth's atmospheric system known as general circulation models or GCMs. As has been mentioned, these are numerical weather prediction models that simulate climate processes over long periods of time. They are generally based on five prognostic variables: temperature, humidity, surface pressure and two dimensions of wind, and are used for controlled runs, perturbed usually by changes in CO_2 until they reach an equilibrium level. Generally runs are done on a doubling of atmospheric CO_2 concentrations from pre-industrial levels. The first GCM studies were undertaken by Manabe and Weathereld (1975) at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey. More recent studies have been undertaken at the National Centre for Atmospheric Research (NCAR), the Goddard Institute for Space Studies (GISS), the United Kingdom Meteorological Office (UKMO), and Oregon State University (OSU). A more complete description of these models can be found in Dickinson (1986). The most recent model to appear has been developed by the Canadian Climate Centre (CCC), a branch of the Atmospheric Environment Service within Environment Canada. All of the models show remarkable consistency with observed temperature and precipitation when run at present levels of CO_2, as shown in Figure 2.1. More variation amongst the models exists, however, in comparing their $2xCO_2$ runs. Table 2.1 gives the global average differences in surface air temperature and precipitation simulated with six GCMs.

Although all of the models show a certain degree of warming under conditions of a doubling of atmospheric CO_2, and show strong similarities to existing climate when run under

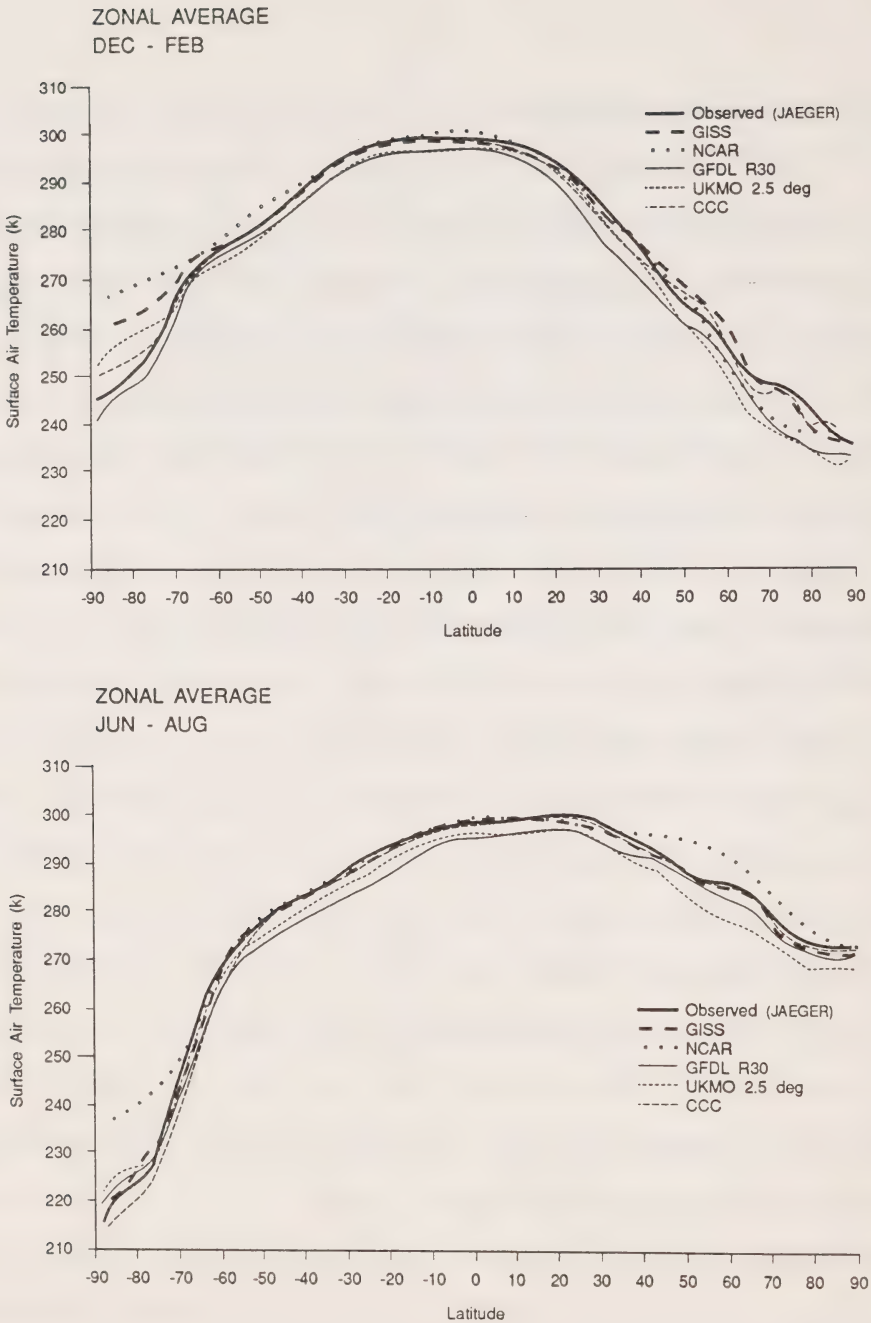

Figure 2.1 Simulation runs of general circulation models vs. observed data.

present CO_2 levels, a number of difficulties are apparent. First, they do not possess a degree of variability that is apparent in the real climate (Katz, 1988). Second, the models cannot provide information about temperature and precipitation changes at a small enough spatial scale to be useful for detailed impact studies. Why is there variation in the projections of the GCMs and what are the main criticisms of their use? Basically, the models reflect an inadequate knowledge of (or our inability to accurately model) the role of clouds and the ocean in atmospheric processes and a general lack of spatial detail. Some of the GCMs incorporate a simple model of the ocean/atmosphere circulation (UKMO, GISS and CCC), while others do not. Most have different levels of resolution, which makes comparison at all but the global scale very difficult. Major criticisms of the models relate to their treatment of five important feedback mechanisms in the climate system which are:

1. Water Vapour
2. Snow and Sea Ice
3. Cloud Cover
4. Cloud Radiative Properties
5. Ocean-Atmosphere Interface

(A more complete description can be found in Mitchell, 1989; Jenne, 1989; and Tucker, 1989). The difficulties incorporating these feedback mechanisms into the climate models, and their potential importance in mitigating any tendency towards global warming, has contributed to the controversy surrounding the issue. Much of the work currently being conducted on the climate models is centred on these issues.

Although it is not the purpose of this study to include a detailed analysis of the deficiencies and criticisms of the general circulation models, the preceding comments do indicate some of the difficulties in projecting climate change even with accurate information on greenhouse gas emissions. Translating relatively small amounts (relative to global totals) of additional greenhouse gas emissions from a particular source to expected temperature and precipitation changes, therefore, is an extremely tenuous process.

Table 2.1. Comparison of global results under 2xCO2 simulations for six general circulation models.

Model	δ Temp (deg. C)	δ Precip (% $1XCO_2$)
OSU	2.8	8
CCC	3.5	4
NCAR	4.0	7
GFDL	4.0	9
GISS	4.2	11
UKMO	1.9-5.2	2-15

C. Regional Description

Figure 2.2 is a map of the region studied. It includes the three rivers used as case studies, all of which are described in more detail, below. The river systems vary considerably in length and volume of water carried, and each deserves a more comprehensive analysis than this overview provides. The purpose of this project, however, was to offer some initial insights into the potential for climate warming to cause conflicts and not to present specifics on each sub-region or sub-basin. To better assign climate projections, the study area was arbitrarily divided into three regions, noted as; 1) the Jordan-Litani; 2) the upper Nile; and 3) the lower Nile.

Litani River: The Litani River flows entirely within the boundaries of Lebanon (Figure 2.3). The river system can be separated into three main parts; upper, middle, and lower basins. The upper basin is situated in a long narrow valley known as the Bekaa Valley and is sandwiched between the Lebanon Mountains to the west and Anti-Lebanon Mountains to the east. The Litani flows south between these two mountain ranges. Upon reaching Lake Qirwan the middle basin of the Litani begins. In the rugged terrain of the southern portion of the Lebanon Mountains the Litani enters a deep gorge and then alters its southernly course and heads west towards the Mediterrean Sea. At this point where the Litani changes direction it enters into its lower basin. The rugged terrain characteristics of the middle basin gives way to the low hills and steep slopes of the Galilean Uplands. The river flows through the lower basin until it reaches the Mediterrean Sea.

The precipitation that falls on the middle basin and the Lebanon Mountains is the water source for the Litani River. The amount varies substantially from location to location and even

Figure 2.2. Map of the Middle East.

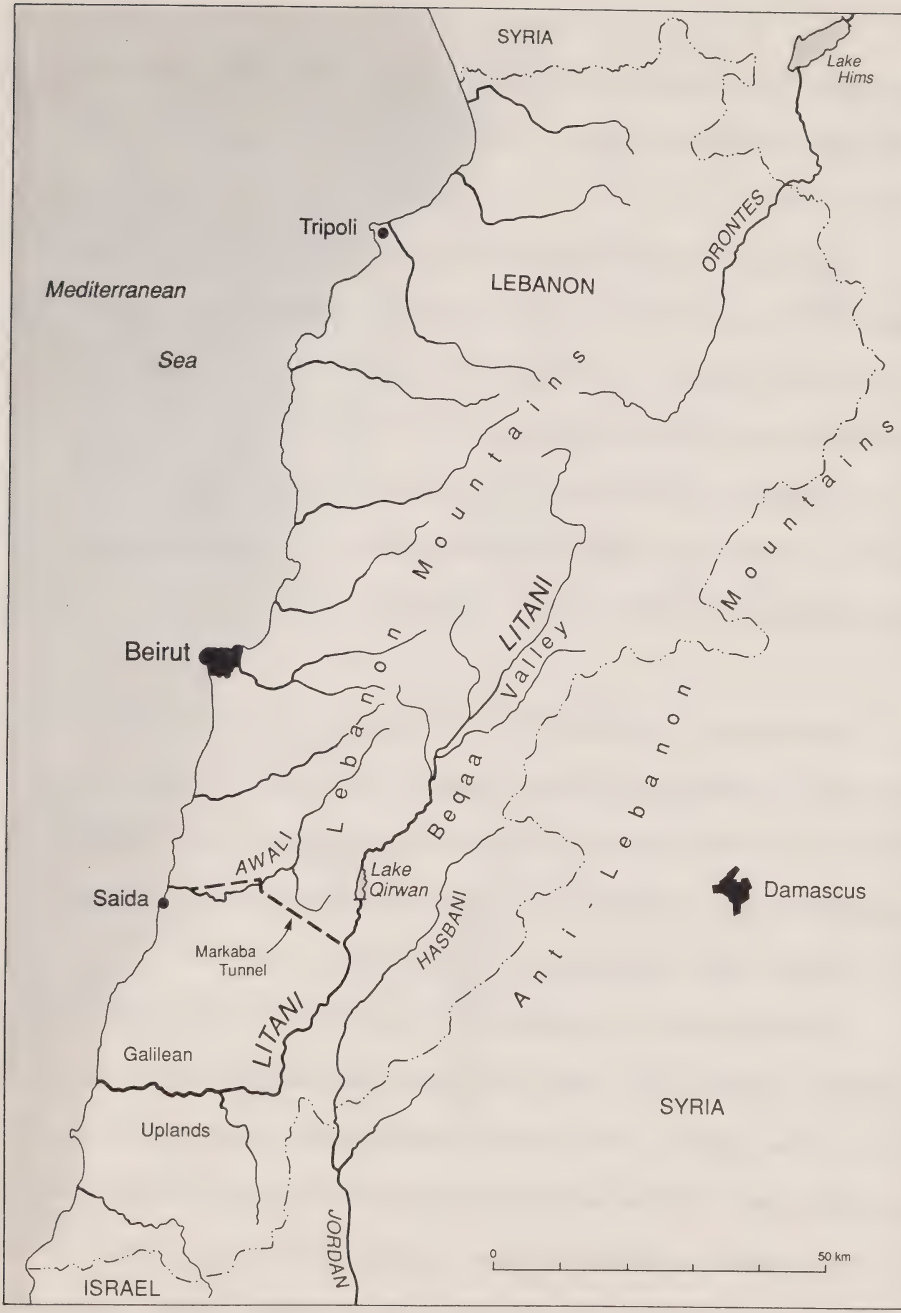

Figure 2.3. Map of the Litani River and surrounding environs.

from year to year. Most rain falls on the Lebanon Mountains and the middle basin and ranges from 1000 mm to 1600 mm annually, while the lower basin receives about 800 mm annually (Hudson, 1971).

The annual flow of the Litani amounts to 700 million cubic meters (MCM). Of this annual flow the upper basin contributes 325 MCM, the middle basin 315 MCM and the lower basin 60 MCM (Hudson, 1971). During the cool, moist months of the winter the Litani is at its highest level (60-65% of average annual flow), while in November and December the Litani is at its lowest level (10% of the average annual flow). Annual consumption of water within Lebanon is 750 MCM/yr; agriculture accounts for 87% while domestic and industrial use makes up the remaining 13% (World Resources, 1988-89).

Jordan River: The Jordan River is a relatively short, but complex system (Figure 2.4). The tributaries of the Jordan originate in southern Lebanon, northern Israel, and western Syria. The river flows south through the Jordan Rift Valley and empties into the Dead Sea, with a total length of 320 km. In this relatively short distance the annual precipitation changes from more than 1000mm around Mount Hermon to 50mm at the Dead Sea.

Three river systems, the Hasbani, the Dan and the Baniyas rivers make up the source waters for the Jordan river. Each of these rivers originates on either the western or southern slopes of Mount Hermon. The three rivers eventually meet in the Valley of Lake Hula to form the Jordan River. From this point the Jordan River flows into Lake Tiberias, a slightly saline lake with a volume of 4 cubic kilometres covering an area of 168 sq km. Ten kilometres downstream from Lake Tiberias the Jordan is joined from the east by the Yarmuk River. The

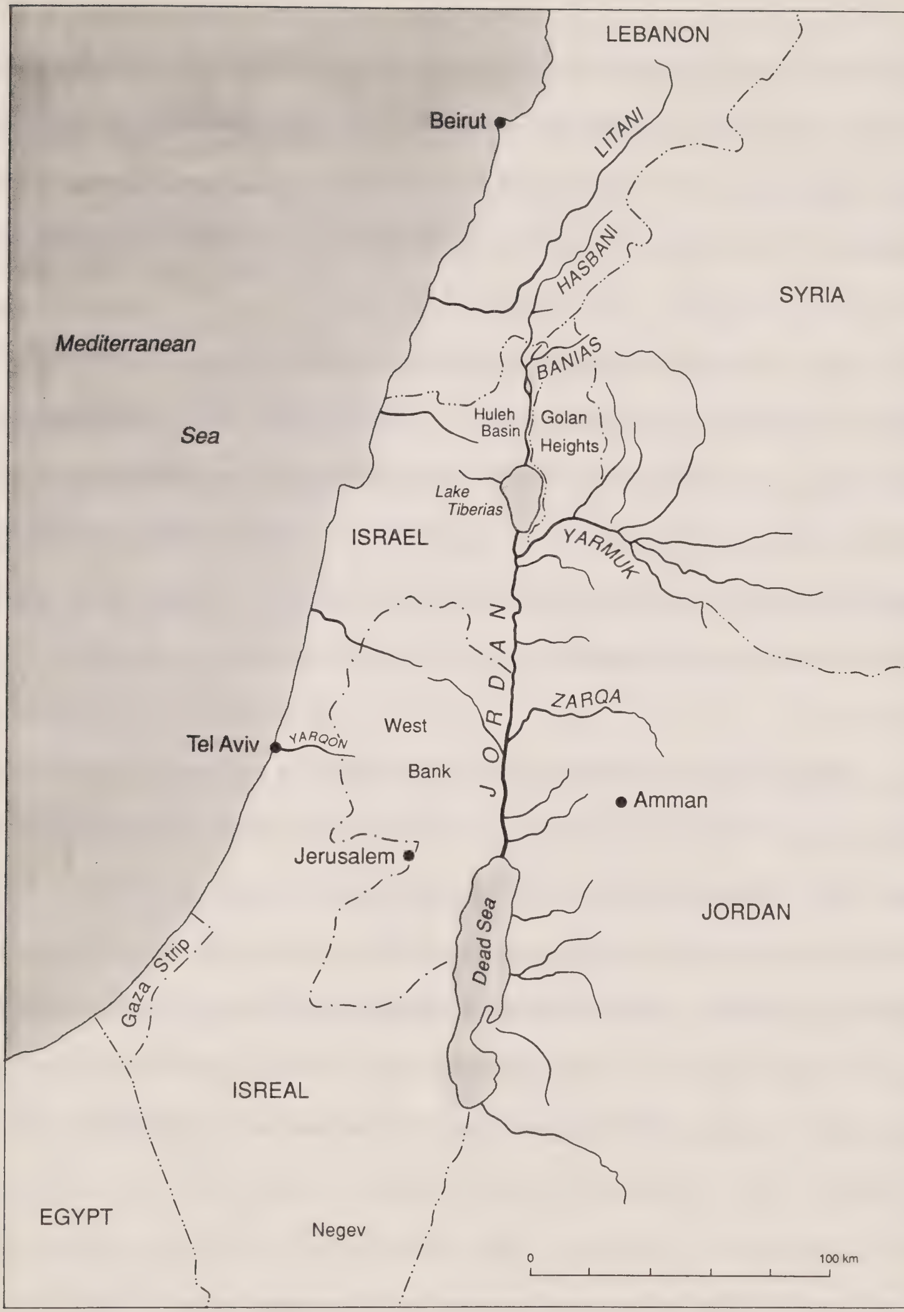

Figure 2.4. Map of the Jordan River and surrounding environs.

Yarmuk River forms two important borders, one between Jordan and Syria and the other between Jordan and Israel. The Jordan continues its southernly course past the intersection with the Yarmuk twisting and winding through the Rift Valley, where it eventually drains into the Dead Sea. The Dead Sea itself is a hypersaline waterbody with an area covering 940 sq km and a volume of 147 cubic km. (Por and Ortal, 1985).

Upon reaching the Dead Sea the Jordan River discharges an annual average flow of 1850 MCM. Of this total discharge, the Dan River contributes 245 MCM/yr, the Hasbani averages 138 MCM/yr, and the Baniyas averages 121 MCM/yr. The Yarmuk contributes on average 500 MCM/yr. The area between the Yarmuk and Dead Sea supplies the Jordan with another 523 MCM/yr through winter runoff streams (Naff, 1984). Groundwater seepage and springs along the course of the Jordan River make up the final contributors to the average annual flow of the Jordan River.

The two main riparian states accessing the Jordan River are Israel and Jordan. To both of these countries the river is an extremely important water resource. It supplies about 50% of Israel's water demands, while 66% of Jordan's water comes from the Jordan River system (Naff and Matson, 1984). Israel's total annual demand for water in 1986 was 1700 MCM/yr of which agriculture consumed 79%, domestic usage accounted for 16% and 5% was industrial use (McDonald and Kay, 1988). Jordan's total annual consumption was 555 MCM/yr in 1980, and agriculture accounted for 84%, domestic use 11%, and industrial use 5% (Naff, 1984).

Nile River: The Nile is the longest river in the world, extending 6700 km from its source in Lake Victoria to its delta on the Mediterrean Sea (Figure 2.5). The two main branches of the Nile are the Blue Nile and the White Nile. The White Nile is fed by Lake Victoria and other smaller Rift Valley lakes, while the Blue Nile is fed by Lake Tana in the Ethiopian highlands.

From the Rift Valley in Uganda the White Nile flows north out of Lake Victoria towards Sudan. As the Nile exits this equatorial highland it descends into the swamplands of southern Sudan called the Sudd, where it is joined by the Sobat River. The White Nile continues flowing north where it is met at Khartoum by the Blue Nile. The next and last tributary that the Nile encounters is the Atbara River, which originates in the Ethiopian Highlands. From this tributary the Nile flows northwards across the desert, at times through narrow canyons, while at other times it broadens onto flat and fertile land.

During its journey from Lake Victoria to the Mediterrean Sea, the Nile travels through three climatic zones. The White Nile, which flows out of Lake Victoria, has an even and regular flow throughout the year. This can be attributed to the wet tropical climate in the Lake Victoria area. The amount of water that leaves the Sudd is estimated at 14000 MCM/yr (Naff, 1984). The Blue Nile, on the other hand, has an irregular seasonal flow. Between the months of August and October the Blue Nile discharges about 80% of its annual flow (Smith, 1986), a result of the Ethiopian Highlands receiving the greatest amount of precipitation during the monsoon season, which occurs during this period. The Blue Nile contributes just over half the waters of the Nile downstream from Khartoum (Sale, 1983). The amount of water that the Blue Nile carries is 48000 MCM/yr, while the Atbara River contributes another 12000 MCM/yr, both

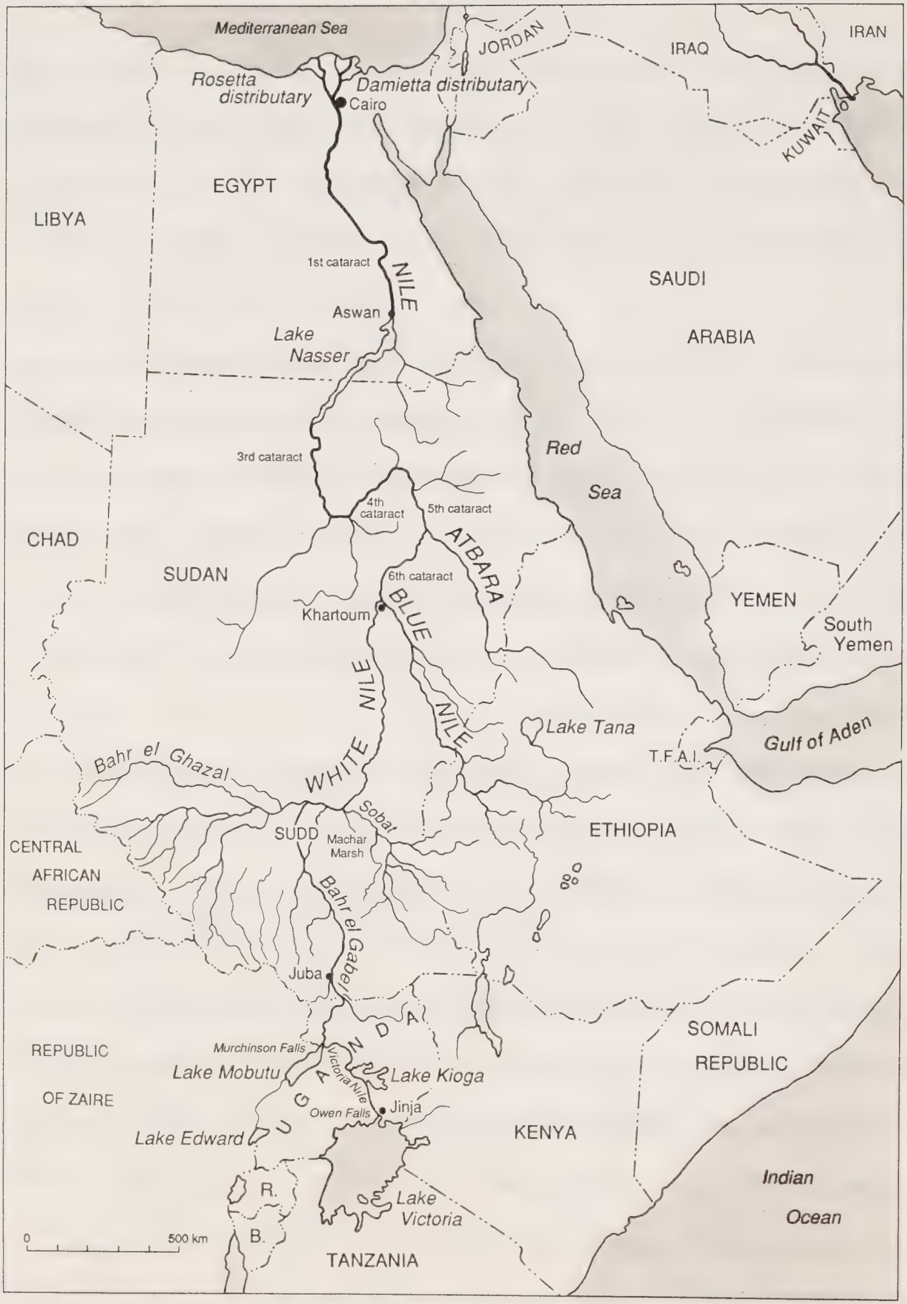

Figure 2.5. Map of the Nile River and surrounding environs.

of which occur mainly in the late summer flood (Naff, 1984). The annual consumption of water within Egypt is 56,400 MCMs (1985) with agriculture accounting for 88 %, industry 5%, and public use 7%. The annual consumption of water within Sudan is 18,600 MCMs (1977) with agriculture accounting for 99% and industry and public use making up the remaining 1% (World Resources 1988-89).

D. Present Climate in the Middle East

The general climatic characteristics of the Middle East reveal why water is such an important resource. Wide seasonal temperature fluctuations and irregular rainfall patterns are typical of the region. Summers are hot and dry, while the winters are relatively mild and rainy, with substantial regional variation. Whether the precipitation is abundant (Lebanon Mountains) or slight (Negev desert) it will occur sometime during the rainy winter season between September and April, with January and December exhibiting the heaviest monthly precipitation. The only exception to this pattern is the Ethiopian Highlands, which are affected by monsoon rains during the months of August to October. One other exception is the higher elevations which can receive significant summer rainfall.

The amount of precipitation in the Middle East is determined by two main factors. First, proximity to a major moisture source, such as the Mediterrean Sea, and second, altitude above sea level (Beaumont et al, 1976). Regions receiving the highest amount of precipitation, such as the Lebanese Mountains, are characterized by both of these elements. Areas such as the Negev desert, while close to the Mediterrean Sea, do not receive the necessary uplifting of air to produce a substantial amount of precipitation.

The rainy season is an essential and important part of the Middle Eastern climate, since it is not only the origin of all water, but is also a time when temperatures are relatively low. Evaporation of water is therefore reduced, enabling any excess moisture to either be stored in the soil or used to recharge the rivers.

Wide seasonal fluctuations in temperatures can also be attributed to the climate of the Middle East. Most of the region can be represented by a B type climate (Koppen classification system), characterized by a dry realm where precipitation is exceeded by potential evapotranspiration. Evapotranspiration, one feature that may be significantly influenced by climate warming, depends on two main factors, the average monthly air temperature and latitude, the latter controlling the length of daylight.

B type climates typically include a wide range of temperatures and precipitation values. This poses difficulties when applying general climate change projections to the region (as is the case in all regions). Cairo, Egypt, for example, has an average yearly temperature of 20° C. and an average precipitation of 26 cm., and is classified as a BW type climate, or desert. Amman Jordan, with an average annual temperature of only 17.5° C. and a similar annual precipitation to Cairo is classified as a BS climate, or steppe. This presents difficulties in applying the climate projections (below) to impact models, since the projections mask the regional variations that occur, and there is difficulty in comparing the projections to observed data. Climate data on the Middle East is collected for major centres such as Cairo and Amman, but because of the regional variations cannot be compared to the climate change projections produced by the GCMs (in any way that promotes useful comparisons). Nevertheless, the

majority of the Middle East can be represented by a B type climate with pockets of highlands (Ethiopian & Lebanon) and Mediterrean climates (coast of Israel & Lebanon).

The climate classifications are useful, however, in determining the potential extent of agriculture development, vegetation patterns, and human use of the environment (Beaumont et al, 1976). The Middle East is limited in agriculture development potential because of its climate. In order for crop germination to be successful an area needs a warm temperature and a sufficient supply of water, and while temperatures are sufficient, precipitation levels in the region are a major deterrent to further development. Not only do many regions in the Middle East have sparse precipitation, but, additionally, rainfall is also highly irregular. Total precipitation in some years will only be 50% of the yearly average. Evapotranspiration rates offer a more reasonable view of potential water availability and water demand than precipitation alone, since they take into account precipitation as well as temperature. Irrigation can supply the extra water needed, but using water for irrigation is a highly consumptive use when compared with domestic or industrial use, and is a major constraint to development in certain regions. As noted below, irrigation accounts for over 80% of the water consumed in the region, and continued development of the agricultural system will greatly strain existing water supplies.

E. Climate Change in the Middle East

The output of three GCMs were used in this study to project temperature, precipitation and solar radiation under a doubling of carbon dioxide levels in the atmosphere for the Middle East. Using the Jodan-Litani, upper Nile and lower Nile River basins as the focus for the application of climate warming projections, grid cell output was assigned to one of the three

regions. Figures 2.6 - 2.8 illustrate the three regions and the point assignment of climate projections from each of the three models, where the points denote the centre of the grid cell. The number of data points varies from region to region as well as from model to model, an indication of the differing spatial levels of the models. Using aggregate climate data such as that generated by the GCMs masks regional and local variation in climate parameters; this may be of greater concern when dealing with small river basins such as the Litani in Jordan. In some models, such as the GISS, the grid cells are quite large, and including as few as four data points often means that climate data from 1000 km distant is assigned to the basins. In addition, existing time series data on simple climate parameters such as temperature are deficient in the region and drawing comparisons between past and present temperatures, for example, and the models' outputs is not appropriate. Most climate data for the region is concentrated in urban areas, with one or two sites often comprising the entire data record for a country. The data presented here should be viewed as general climate parameters under a $1xCO_2$ atmosphere (pre-industrial levels) and a $2xCO_2$ atmosphere.

1. Temperature

Table 2.2 presents the increase in temperature in the three regions projected by each of the GCMs, by season and annually. The GFDL and GISS models exhibit increases of between 3.5 and 4.2 degrees C for all regions, with the UKMO model showing increases of 4.5 to 6 degrees and consistently higher than the other two over all seasons. This information, as well as the absolute temperature under the $1xCO_2$ and $2xCO_2$ scenarios for each of the regions under the GFDL scenario and the percent increase in temperature are presented graphically in Figures

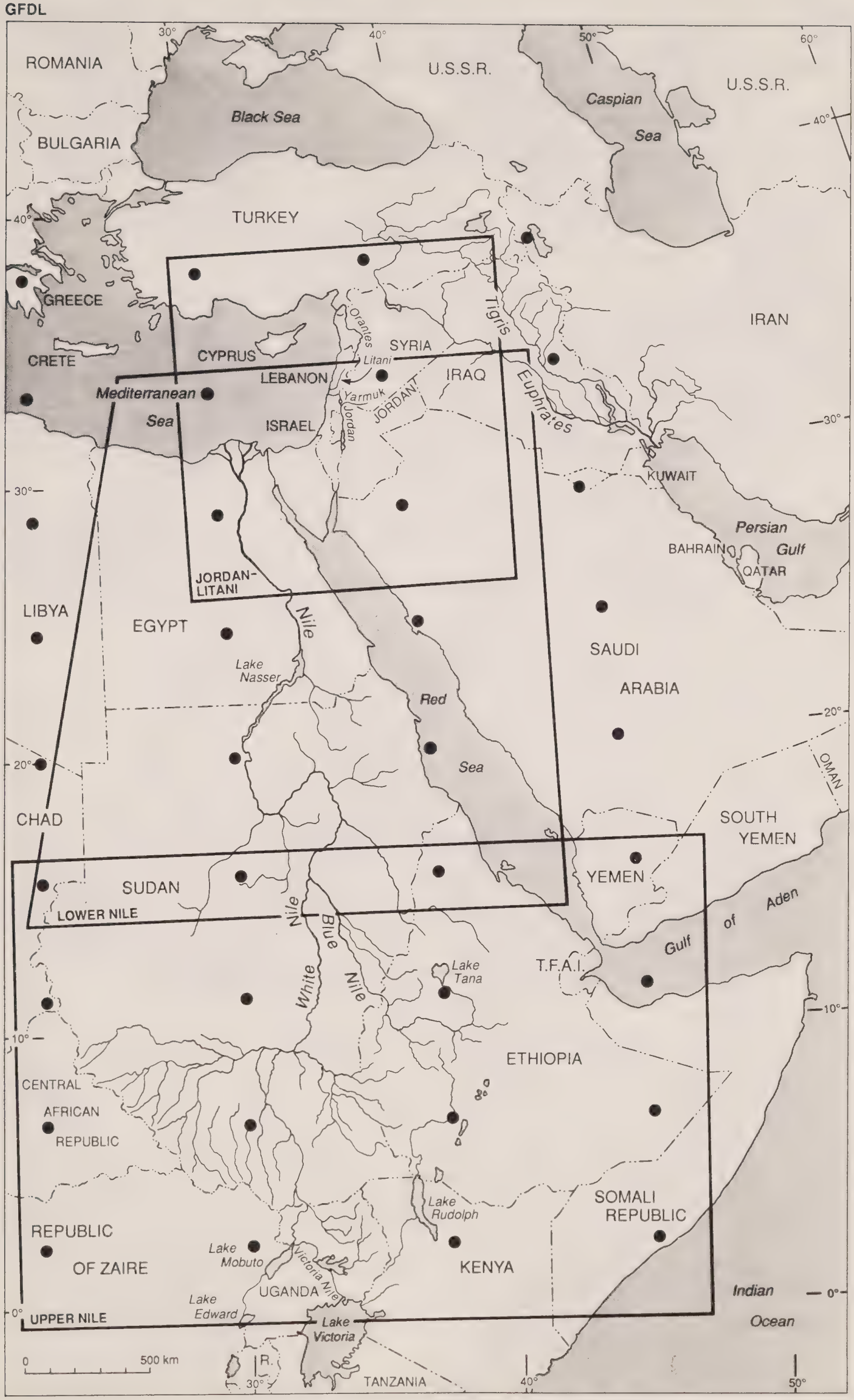

Figure 2.6. Map of the Middle East with GFDL grid cells, apportioned by river basin.

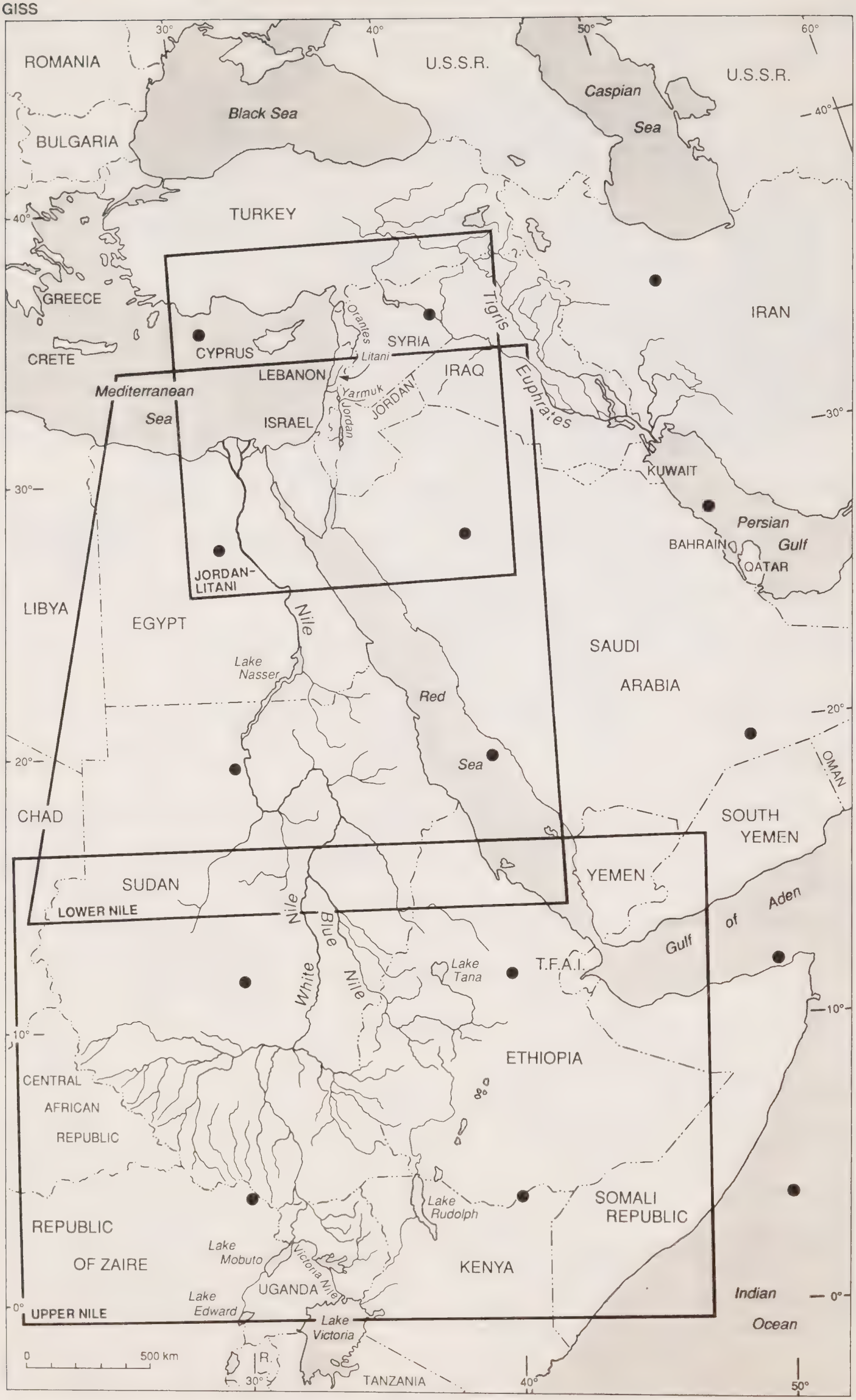

Figure 2.7. Map of the Middle East with GISS grid cells, apportioned by river basin.

UKMO

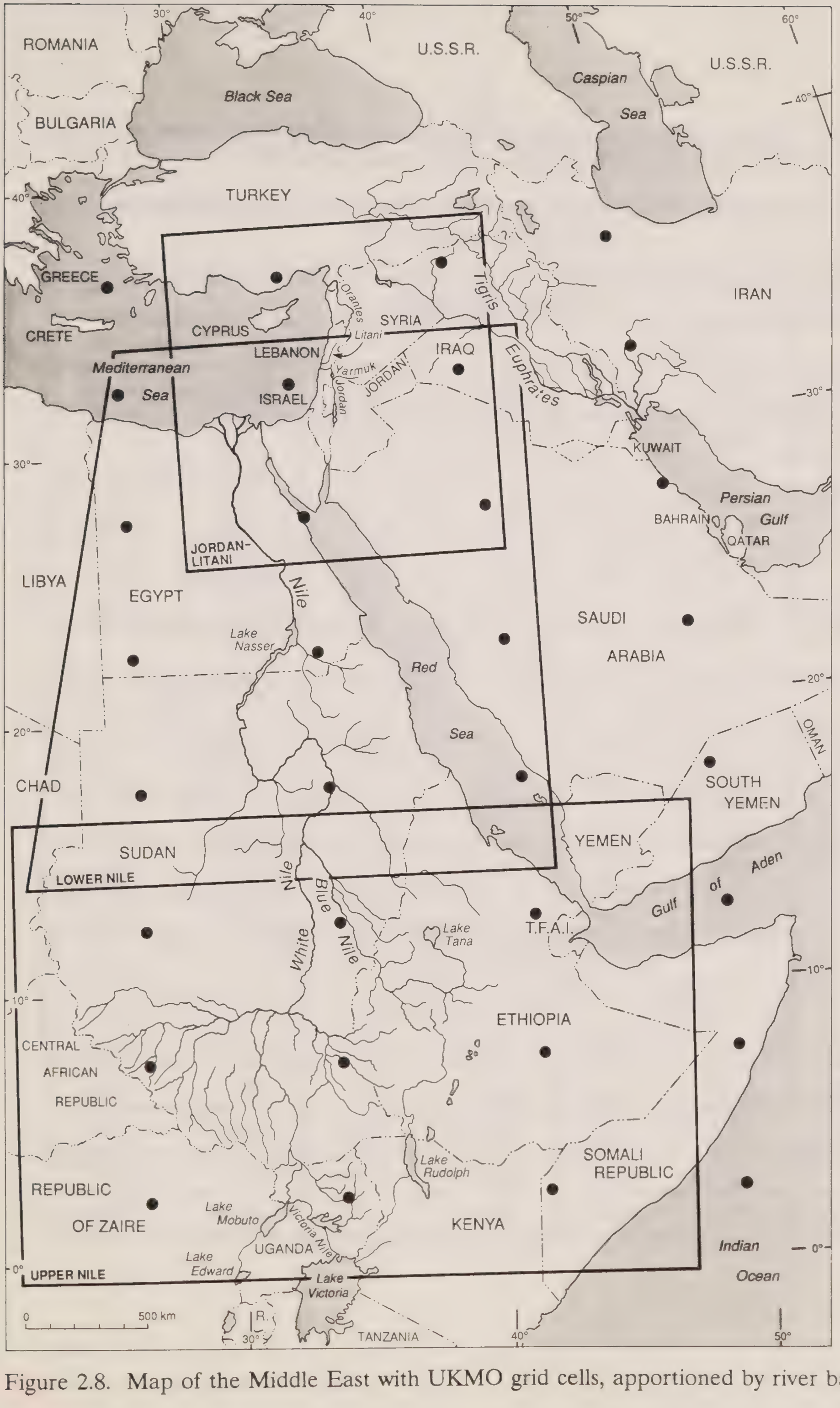

Figure 2.8. Map of the Middle East with UKMO grid cells, apportioned by river basin.

Table 2.2. Temperature scenarios for the Jordan-Litani River Basin under $1xCO_2$ (pre-industrial) and $2xCO_2$ levels, according to three GCMs.

Temperature (degrees C.)						
JORDAN-LITANI						
	GFDL		UKMO		GISS	
season	2xCO2	1xCO2	2xCO2	1xCO2	2xCO2	1xCO2
DJF	8.06	3.91	16.97	11.26	14.68	10.66
MAM	16.98	12.51	24.98	18.19	22.50	18.42
JJA	29.78	25.64	34.07	27.13	33.59	30.06
SON	20.55	16.23	28.76	22.12	24.68	20.09
Annual	18.84	14.57	26.19	19.68	23.86	19.80
LOWER NILE						
	GFDL		UKMO		GISS	
DJF	14.59	10.60	19.73	13.90	17.93	13.51
MAM	23.28	19.11	29.11	22.07	25.29	20.99
JJA	32.17	28.15	35.70	28.74	33.28	30.41
SON	25.08	20.48	29.68	23.37	25.82	21.48
Annual	23.78	19.59	28.56	22.02	25.58	21.60
UPPER NILE						
	GFDL		UKMO		GISS	
DJF	23.14	19.86	28.13	23.10	24.78	20.25
MAM	25.65	22.62	28.21	23.81	28.57	24.64
JJA	26.71	23.29	27.53	22.62	28.39	26.21
SON	25.82	22.10	26.28	22.36	26.41	22.73
Annual	25.33	21.97	27.54	22.97	27.04	23.46

1 - 9 in Appendix I. Temperature increases from 15% in the GFDL and GISS projections for the upper Nile to over 30% in the UKMO output for the Jordan-Litani region.

While there is some variation in the temperature projections provided by the three GCMs, there is general consistency within regions, with the UKMO model predicting slightly higher temperatures than the other two. Despite the different assumptions used in the models, and that they operate at different spatial scales, they all project increases in temperature throughout the region of 15% to 30%.

2. Precipitation

Table 2.3 presents the change in precipitation projected by the three models for all regions. This information and estimates of absolute precipitation for the GFDL model for the three regions under a 1xCO_2 and a 2xCO_2 scenario are presented in Appendix II (Figures 1 - 6). Unlike the temperature projections presented above, the precipitation projections show little consistency across models, even within a given river basin region. The GISS model projects higher precipitation amounts annually in all regions, and increases in almost all seasons. The other two models, conversely, show decreases - or marginal increases - in annual precipitation across regions. Figures 7 - 9 in Appendix II illustrate the percent increase in precipitation in each of the regions by model. Note that the large percent changes in precipitation during the summer months (June, July and August) do not reflect large absolute changes; the rainfall during these months is very low, and large percentage changes correspond to only small absolute changes.

Table 2.3. Precipitation scenarios for the Jordan-Litani River Basin under $1xCO_2$ and $2xCO_2$ levels, according to three GCMs.

Temperature (degrees C.)						
JORDAN-LITANI						
	GFDL		UKMO		GISS	
season	2xCO2	1xCO2	2xCO2	1xCO2	2xCO2	1xCO2
DJF	1.78	1.81	0.74	0.88	1.99	2.05
MAM	1.21	1.61	0.80	0.94	1.05	1.24
JJA	0.10	0.19	0.78	0.99	1.14	0.63
SON	0.82	0.80	1.12	1.03	1.73	1.66
Annual	0.98	1.10	0.86	0.96	1.48	1.40
LOWER NILE						
	GFDL		UKMO		GISS	
DJF	0.95	0.96	0.50	0.56	1.57	1.66
MAM	1.11	1.19	0.82	0.86	1.15	1.03
JJA	0.44	0.51	1.12	1.25	20.7	1.02
SON	0.60	0.76	0.98	0.72	2.06	1.88
Annual	0.78	0.86	0.86	0.85	1.71	1.40
UPPER NILE						
	GFDL		UKMO		GISS	
DJF	1.67	1.44	1.09	1.15	3.27	2.84
MAM	3.83	3.63	6.46	5.36	4.10	3.01
JJA	2.76	3.08	4.15	4.05	6.45	4.69
SON	3.09	3.18	5.60	3.95	4.99	4.64
Annual	2.84	2.83	4.33	3.63	4.71	3.80

The variability in precipitation projections across models is characteristic of the degree of our knowledge about precipitation dynamics and the large regional variation in precipitation that occurs over quite small areas. As noted previously, the models often differ greatly in their precipitation estimates, and one must be careful to use them as alternative scenarios rather than select a single model output for analysis.

3. Evaporation

What influence will these expected temperature and precipitation levels have on other factors in the region? One of the most important will be the impact on evapotranspiration, which will affect water supply (discussed in the next chapter). Although detailed data on surface water availability and use are not readily accessible for the Middle East, rough estimates of the change in evaporation due to climate warming were made to illustrate the potential impact on water availability. Most of the water consumption in the three river basins discussed in this paper is from surface water supplies. Two natural factors may affect the amount of water available for human consumption in the future; precipitation and evaporation. Changes in evaporation resulting from climate warming were approximated using a combination of energy-budget and mass transfer approaches based on the Penman equation (Penman, 1948). The equation is, as follows:

$$E_0 = \frac{\frac{\Delta}{\gamma} H + E_\alpha}{\frac{\Delta}{\gamma} + 1}$$

Where: E_0 is evaporation rate;

H is net solar radiation;

Δ is the slope of the curve relating vapour pressure to temperature;

γ is the psychometric constant; and

E_α is a term describing the contribution of mass-transfer to evaporation.

Figure 2.9 illustrates the change in evaporation for the three river basins under the GISS model. These results indicate only the general magnitude of the change in evaporation under the GISS scenario. Projections range from an increase in the rate of evaporation of two and a half percent for the lower Nile to six percent for the Jordan-Litani under a doubling of CO_2 levels in the atmosphere.

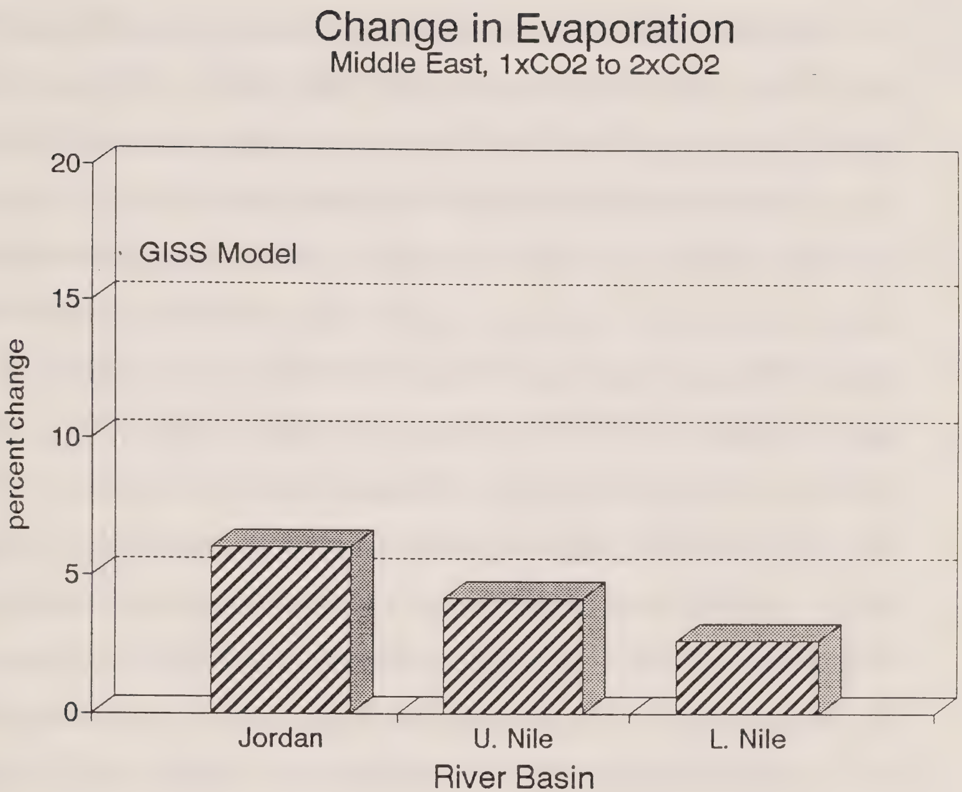

Figure 2.9. Change in evaporation by river basin, according to GISS model ouput.

III. WATER RESOURCES IN THE REGION

A. Introduction

As mentioned previously, many of the most important issues in the Middle East today relate to water. Although international attention usually focuses on the region's energy resources, water has been a major factor in the outbreak of wars and the formation of alliances for many centuries, and this trend is likely to continue long after oil reserves in the area have been depleted (Cooley, 1984). Water is necessary to sustain life, agriculture, industry, energy production, and recreation. It is linked to disease as well, and as recent years have shown, drought or flooding can have devastating impacts. Therefore, a secure supply of water and control of available sources is a central component in almost all national planning policies, particularly where the resource is limited (Falkenmark, 1986). In the Middle East, one of the world's most arid regions, water is increasingly scarce, and a potentially severe problem is emerging - the threat of a major water shortage. It has been estimated by the U.S. Department of Agriculture that 90% of the water used in Saudi Arabia, for example, comes from underground aquifers and that this resource may be depleted within 10 - 20 years in the absence of any controls on consumption (Economist, May 12, 1990). Galnoor (1980) predicted that Israel would not be able to meet its water needs by the early 1990s without acquiring additional supplies (indeed, Israel has already begun to import water from Turkey; Ottawa Citizen, November 25, 1990).

The Middle East's water problems stem largely from the area's climate; but in addition to the natural conditions, the problem of water scarcity is now being exacerbated by other

factors. A rapid growth in population is leading to substantial new demands on water resources, and an increasing rural-urban migration is resulting in more limited access to supplies and a need to transfer water over long distances. Additionally, an increasing use of irrigation in agriculture and attempts throughout the region to develop industrial capacity compete with domestic use for fresh water (Heathcote, 1983). Although unsubstantiated, Egyptian government officials now believe that Israeli water engineers have been helping Ethiopia plan irrigation projects on the Nile, which could significantly reduce the amount of Nile River water available to Egypt (Economist, May 12, 1990). All of these changes put great pressure on the already inadequate water supply in the Middle East.

Increases in demand have also begun to induce a cyclical problem of decreasing water quality. As more water has been required, the initial response was to stimulate supply, and numerous water re-use programs were implemented. These projects, however, have often been unaccompanied by adequate safeguards for health and sanitation concerns, resulting in water of poor quality (Fahim, 1981). Concurrently, domestic and industrial waste discharges contributed to water quality deterioration, and the subsequent disposal of sewage and contaminated water into the water systems has also caused tremendous problems (Beaumont et. al., 1988). As a result, the goal of preserving and managing water resources must now include attempts to protect water quality.

Because of the importance of the issue, governments throughout the region have given high priority to water resource policy. Technology has long been seen as the answer for resource problems, and in the Middle East, with water supplies approaching exhaustion, great urgency is attached to searches for alternative sources (Anderson, 1988). Innovations in drilling

and pumping techniques have made previously unknown or unobtainable supplies available, and these have had major impacts on development in the region (Heathcote, 1983). One technique used is desalination, the process of separating water from dissolved impurities to produce a relatively pure water source.

The Middle East has invested more money in developing this technique than any other region, and now possesses more than thirty-five percent of the world's desalination plants and more than sixty-five percent of global desalting capacity (Awerbuch, 1988). Despite this progress alternative sources developed to date have proven highly uneconomical and prohibitively expensive on a scale that would be necessary to meet the impending water crisis (Frey and Naff, 1985). Extensive efforts to boost converted salt water to a major component of consumption in Israel, for example, have resulted in a contribution of just over 2% of total supply. Also, most Middle Eastern water facilities are poorly managed and inefficient, infrastructure facilities are inadequately maintained, and few governments in the region have consistent water planning (Calleigh, 1983; Starr and Stoll, 1988). As a result, in spite of attempts to develop alternative sources, all of the region's countries remain dependent on tapping the river systems in the area (Cooley, 1984).

A reliance on surface water sources and, in particular, on the rivers in the region makes the issue of water scarcity not simply a technical one but also politically significant as well. The boundaries of water resources are not necessarily the same as political ones, and extraction at one point of the river may seriously effect supply at another. The quantity and quality of water reaching downstream countries in a river basin, then, is dependent upon activities upstream which may either reduce flow or degrade the quality of the source. Unless the flow of water

is adequate for all needs, measures taken by upstream riparians which threaten supplies of downstream states will create strong feelings of uneasiness among the latter (Falkenmark, 1986a, 1990). In the Middle East, this situation is of great importance, as many rivers in the area are shared by a number of nations very dependent on them as a resource source.

> ...the region's water resource quagmire is even deeper than technical, management, or even economic constraints would suggest. More difficult to assess and alter are underlying passions. Although physical conditions may vary from nation to nation, attitudes about water do not. In every country, access to clean water is considered an undeniable right, and tampering with water supplies is considered an unspeakable crime.
>
> (Starr and Stoll, 1988, p. 154)

The water issue is a possible vehicle for cooperation if the Middle East states recognize the necessity of sharing the region's resources. Political agreement is very rare in the Middle East, however, perhaps even scarcer than the region's water (Chesnoff, 1988). Thus, political and emotional issues may pose an even greater challenge to the region than changes in physical conditions.

Water availability, then, appears to be a highly complex issue. It is essential to existence, and yet water management is a difficult problem as it must be dealt with in practical, ideological and symbolic terms. As Falkenmark (1986a) suggests, the traditional approach to natural resource problems has been to discuss them in fragmented fashion, viewing food, agriculture, forests and the human sector as non-related. Instead, the interrelatedness of issues must be taken into account, since water is not just a technical commodity. Water is often taken for granted, and utilization of it has been conditioned by the comfortable notion that it is a limitless and free resource (Thompson, 1978). The result of such an attitude, however, is a

growing water shortage in many regions of the world, and under extreme conditions it can lead to serious conflict.

Some studies suggest that water has already been the cause of violent confrontation in the Middle East. Competition for control of the Jordan, the Litani and other river systems in the area may have been a principle cause of the 1967 Arab-Israeli war, and tension continues to accompany development plans for any of the rivers (Calleigh, 1983; Cooley, 1984; Naff and Matson, 1984; Westing, 1986). In a water scarce region like the Middle East, where margins of tolerance are already narrow, even small changes in water consumption and supply can result in quick and widespread repercussions, and can impact significantly on relations between states sharing common water sources (Frey and Naff, 1985).

The marginal value of water to the economies of some countries in the region is very high. Israel, for example, is currently consuming over 95% of its renewable fresh water sources (est. at 1600 MCM/yr.). Additional water from reclamation and desalinization is not expected to meet the growth in water demand (Galnoor, 1980). Furthermore, increases in the urban population and continued economic growth will necessitate 800 MCM of additional water supplies by the year 2000, either from new supplies or by diverting water from agriculture to domestic use (Naff and Matson, 1984). Although waste water reclamation has added almost 25% to total water supplies, it is an expensive process, utilizing significant energy and capital inputs. A shortage of water, however, could have significant consequences for the Israeli economy. In addition, water has the highest marginal value (shadow price) of any sector in the Israeli economy (Kubursi, 1982), and Israeli incursions into the security zone in southern Lebanon have been criticized because of the perceived desire of Israel to divert Litani River

water for its own use. By the year 2000, it is expected that emerging water shortages, combined with a deterioration in water quality, will leave insufficient water to satisfy the growing human, developmental and security needs among all nations of the Middle East, and this will lead to desperate competition and conflict (Naff and Matson, 1984; Starr and Stoll, 1988). As a result of this natural resource crisis, it is expected that the already fragile ties among the regional states may be destroyed, and Heller (1990) predicts "a general, sustained, vicious resource competition within and between states increasingly armed with long-range delivery systems and unconventional weapons of mass destruction" (p. 170). If such a prediction should prove to be correct, the effects will most certainly be felt outside of the Middle East, and conflict in the region would likely involve Canadian interests.

B. The River Systems

1. The Jordan River

The Jordan River has been referred to as the "river basin in which competition for water is stronger than anywhere else in the world" (Falkenmark, 1986, p.87). Four riparian states border the river, Israel, Jordan, Lebanon and Syria (Figure 2.3). Even before the Arab-Israeli war of 1967, the various states had attempted to begin water development projects based solely on individual needs and often thwarting each other's use of the river (Calleigh, 1983). Israel consistently resisted - often by force - Arab attempts to divert Jordan River water or any changes in land use that might have impacted the downstream availability of water. The occupation of the Golan Heights and the West Bank by Israel after 1967 significantly improved its hydrostrategic position (Naff and Matson, 1984). Israel increased its control over the Yarmuk

River from 10km to half the river, which made any Jordanian development of the river dependent on Israeli consent. The occupation also ensured that rainfall in the West Bank would sufficiently recharge the aquifer supplying half of Israel's water rather than being diverted for other uses. Since the end of the war, there have not been any attempts to reach a formal settlement regarding use of the water source, and political tensions in the area are too high to facilitate cooperation, no matter how beneficial it might be (there has, however, been a tacit acceptance between the two states of the Johnston Plan quotas for many years). Unless consumption patterns change and there is a coordinated effort to redistribute the supply of water in the Jordan River basin, however, there is a high probability that the riparian states will face acute and progressively worsening shortages by the middle of this decade (Frey and Naff, 1985; Naff and Matson, 1984). The usable annual flow of the Jordan River system is approximately 1400 MCM. This supply represents almost fifty percent of Israel's water budget and sixty-six percent of Jordan's needs, as mentioned previously. In addition, the usable water from the Jordan River is about twice that available from all other sources in Israel, and about three times that in Jordan. Thus, while in a precarious situation with rapidly increasing water needs, the major source for both Israel and Jordan is the river they share.

a) Israel:

Israel is an arid country with a limited resource base. Currently, its population is approximately 4.2 million (Table 3.1 and Figure A.3.1 in Appendix III); with a growth rate of almost two percent per year (Table 3.2 and Figure A.3.2), population is expected to reach almost 5.5 million by the end of the century (this figure could be higher if significant Soviet

Jewish immigration continues). In addition to continued population growth, there has also been a general increase in the standard of living which puts an added strain on the water supply network, and gross domestic product (GDP) has increased more than six-fold since 1960 (Tables 3.3, 3.4 and Figure A.3.3). As a general rule throughout the Middle East, detailed water statistics are not available, as the continued strife in the region has largely

Table 3.1. Population data, 1960 - 1989, selected Middle East countries.

POPULATION SIZE (millions of persons)							
	1960	1965	1970	1975	1980	1985	1989
Egypt	25.5	29.4	33.1	37.0	42.3	46.8	51.4
Ethiopia	20.0	22.6	25.5	28.8	31.1	36.5	48.7
Sudan	11.2	12.5	13.8	16.5	18.7	21.6	24.2
Israel	2.1	2.6	3.0	3.5	3.9	4.3	4.5
Jordan	1.7	2.0	2.3	2.7	3.2	3.5	4.1
Lebanon	1.9	2.2	2.5	2.8	2.7	2.7	2.9
Syria	4.6	5.3	6.3	7.4	9.0	10.6	12.2

Source: World Tables, 3rd ed., 1983; World Resources, 1988-89.

Table 3.2. Population growth rates, 1965 - 1990, selected Middle East countries.

POPULATION GROWTH RATE percent change					
	1965-70	1970-75	1975-80	1980-85	1985-90
Egypt	2.2	2.1	2.5	1.9	2.3
Ethiopia	2.3	2.3	1.5	3.0	2.8
Sudan	2.0	3.3	2.3	2.7	2.9
Israel	2.8	2.8	2.1	2.0	1.7
Jordan	2.9	3.0	3.3	1.5	4.0
Lebanon	2.6	2.2	-0.8	0.1	2.1
Syria	3.0	3.2	3.4	3.0	3.7

Source: World Resources, 1988-89.

Table 3.3. Gross Domestic Product, 1960 - 1985, selected Middle East countries.

GROSS DOMESTIC PRODUCT million U.S. dollars (1980)						
	1960	1965	1970	1975	1980	1985
Egypt	4147.1	5524	7231	13418	23174	37700
Ethiopia	943.4	1358	1784	2669	4088	5400
Sudan	1111	1428	2187	5310	8104	
Israel	1986	3504	5603	13003	21019	26730
Jordan		469	489	873	2906	4220
Lebanon	894	1148	1488	3247		
Syria	895	1208	1793	5598	12905	16980

Table 3.4. Gross domestic product per capita, 1960 - 1985, selected Middle East countries.

GROSS DOMESTIC PRODUCT PER CAPITA (1980 U.S. dollars/person)						
	1960	1965	1970	1975	1980	1985
Egypt	163	188	219	363	548	806
Ethiopia	47	60	70	93	132	148
Sudan	100	115	158	321	434	0
Israel	939	1367	1884	3764	5430	6219
Jordan	0	239	213	323	896	1203
Lebanon	481	534	603	1173	0	0
Syria	196	227	287	753	1437	1605

precluded the preparation of assessments and made much of the information which does exist inaccessible (Naff and Matson, 1984). However, it is estimated that Israel's renewable water resources equal approximately 1500 MCM per year with an additional 300 MCMs added through re-use programs (Beaumont, 1989; McDonald and Kay, 1988) (Table 3.5). Israel's fresh water demand is believed to be about 1700 MCMs per year, although the World Resources Institute estimates it at 1900 MCM (1990), underscoring the difficulty in obtaining accurate water consumption data for the region. The State Comptroller's report, tabled on January 2, 1991, reported Israel's total consumption of just under 1700 MCM, with agriculture consuming 1300 MCM) indicating that the country is already using approximately 95% of its total supply (McDonald and Kay, 1988; Starr and Stoll, 1988).

Table 3.5. Past and present sources of water for Israel.

WATER AVAILABILITY IN ISRAEL Annual Supply (MCM)				
	1972		1990*	
Ground Water		830		840
Sand Aquifer	240		230	
Limestone Aquifer	590		610	
Surface Water		610		650
Jordan Watershed	570		570	
Flood and Storm Water	40		80	
Recycled Wastewater		39		360
Domestic	35		300	
Industrial	4		60	
Desalinated Water		1.0		40

* Projected

Source: Water Resources of the World; Selected Statistics, 1975.

Table 3.6 presents time series data on water use in Israel by sector for the years 1960 - 1987. In addition to a growth in demand, the country also faces the major problem of deteriorating water quality. Increasing levels of sewage discharge are causing nitrate build-ups, the Jordan River is being polluted by oil spills and recreational use, and there is eutrophication from drainage of agricultural fertilizers into the river. Additionally, irrigation is increasing the salinity of the water, and the high level of groundwater use relative to the natural rate of recharge has caused higher salt levels in these sources. Israel is aware of the pollution, but the

issue of supply is so important that problems with quality are expected to continue (Beaumont, 1989). It is expected, then, that Israel's increasing water needs will lead to a resource deficit within the decade.

Table 3.6. Water consumption in Israel, by sector, 1958 - 1987 (million cubic meters).

Year	Domestic	Industry	Agriculture	Total
1958	196	46	1032	1274
1964-65	199	55	1075	1329
1969-70	240	75	1249	1564
1975-76	305	95	1328	1728
1979-80	375	90	1235	1700
1980-81	367	100	1212	1679
1981-82	385	103	1282	1770
1982-83	401	103	1255	1759
1983-84	419	103	1356	1878
1984-85	422	109	1389	1920
1985-86	450	103	1434	1987
1986-87	424	111	1025	1560

Source: Statistical Abstract of Israel, 1985; 1988; Central Bureau of Statistics.

In Israel, however, water is very much associated with other ideologically important issues. Water is essential for irrigated agriculture, and this, in turn, is linked with the Israeli aspiration to "make the desert bloom". In addition, much of the Labour Party's support is in agricultural areas, and there is a constant tension between the water commissioner and

agricultural minister on one hand, and the state comptroller who claims irresponsible management has resulted in a catastrophic water shortage (Jerusalem Post, Jan. 3, 1991). Water is also important in the production of food and energy within the country, and is connected to the nation's defense and national security. Also, the resource is seen to relate to national well-being through recreation, sanitation and other sectors (Frey and Naff, 1985).

As a result of the importance of the resource and its impending decline, a great deal of emphasis has been placed on developing a comprehensive water management scheme (Beaumont et. al., 1988). Efforts to make agricultural techniques more efficient have been quite successful, with improvements in irrigation and shifts from low to high-value crops increasing production with the same water demand (Heathcote, 1983). As well, research on desalination and reuse of water has been given high priority. Improvements in these areas, however, have not allowed supply to keep pace with the continued growth in demand, and the threat of supply exhaustion persists. Because of this, Israel's water planning must now also attempt to address demand, and to reduce inefficient uses. 78% of the water Israel currently consumes is used for agriculture, and substantial reductions in water use by the agricultural sector could help the water situation in the country (Starr and Stoll, 1988). Further conversion to more efficient farming methods, however, would be very expensive, and given the dominant role of the agricultural sector in Israel's politics and economy, it is unlikely that many more changes will be instituted (Frey and Naff, 1985; Starr and Stoll, 1988). Accordingly, it will be difficult for Israel to greatly reduce demand, unless the country concentrates on expensive desalination plants or finds a way to increase substantially the recycling of used water; present sources can scarcely meet current needs let alone supply the higher consumption expected in the 1990s (Cooley, 1984). Israel

realistically has only three options related to obtaining more water; engaging in shared agreements with Arab countries, restructuring the economy to place less emphasis on agriculture, or acquiring water by military means. Although there is a fourth option, importing water, which is currently being exercised by bringing in water-laden tankers from Turkey, it is considered only a short-term, stop-gap measure with few long-term possibilities.

b) The Occupied Territories:

As a result of Israel's water shortage, the state is trapped in what Calleigh (1983) refers to as the "hydraulic imperative". Israeli draws more than forty percent of its water requirements from the West Bank (Naff and Matson, 1984), and the country can ill-afford relinquishing control of the region without facing immediate water shortages and curtailment of its agricultural and industrial development. The West Bank, then, has become a critical source of water for Israel, and this fact may actually be outweighing other political and strategic factors in its continued occupation (Anderson, 1988).

There are three major aquifers in the West Bank. Even before the 1967 war, Israel was already exploiting two of these, and since the war the third source has been accessed for an additional 66 MCM annually (Anderson, 1988). The water in the West Bank is now used in a ratio of 4.5% by Palestinians and 95.5% by Israelis. This difference in use alone is quite controversial, but the debate over Israeli use of water is likely to increase, as demand for water in Israeli settlements is expected to rise dramatically throughout this decade (Kahan, 1987). By 1985 Jewish settlements in the region had already exceeded their quota for water by almost one third (Starr and Stoll, 1988).

In addition, the fact that so much of the West Bank water is being used by the Israelis is an even greater source of potential conflict because the water available in the occupied territory is now exploited to its limit (Starr and Stoll, 1988). Agriculture and domestic use is far beyond the level of natural replenishment and, as a result, the aquifers are being contaminated by seawater. Heavy pesticide use in the region is another source of pollution. Overuse of the basins is causing the water table to fall, and with decreasing quality and salinity seepage, supply could be drastically reduced unless a solution to these problems can be found (Kahan, 1987).

To allow for development and implementation of technical solutions to water problems in the area a significant financial investment is required, and Israel refrains from making such a commitment in the West Bank and Gaza Strip (Starr and Stoll, 1988). Instead, Israel has imposed limits on drilling of additional water sources in parts of the West Bank, and in some cases the allowed level of pumping from wells has been reduced (Kahan, 1987). According to some sources, however, the restrictions have not been applied equitably. For example, in 1980, the U.N. Committee on the Exercise of Inalienable Rights of the Palestinian people found that Israel had given priority to its own water needs at the expense of the Palestinian people. The committee maintains that Jewish settlements are using the limited resources of the West Bank at the expense of Arab farmers, that the water consumption of the Palestinians is restricted to make water available for the Israelis. The authorities also prohibit the Palestinians from drilling new wells while drilling their own. In addition, Palestinian wells average 70 metres in depth while Israeli ones average 300 - 400 metres, resulting in less salinity and greater productivity. When these are built in proximity to shallow Palestinian ones, the latter dry up. Controls also

include prohibiting the Palestinians from farming after 4:00 p.m. and forbidding the cultivation of certain crops. There is also a difference in the price of water charged to the two sectors, as Israeli farmers benefit from subsidized supplies (Frey and Naff, 1985; Kahan, 1987).

Israel's application of restrictions on the Palestinians not only improves its access to West Bank water, but it also extends its control in the occupied territories. This increases resentment and adds to the potential for conflict in the area. According to the U.N. Committee on Palestinian Rights (1980), the Arabs in the West Bank have protested for years to Israeli authorities that their agriculture and economy are being ruined by the unfair water policies, and that the water network supplying the Jewish settlements has drastically depleted the villages' water resources. But the Palestinians have been frustrated in their efforts to change their circumstances and, given no power, they can only watch their wells dry up and turn saline while water is shipped to Israel. This issue is a highly emotional one, and Starr and Stoll (1988) have called the water situation in the occupied territories a time bomb waiting to explode. There is no doubt that the problem is a difficult one, as Palestinian anger about disproportionate use is increasing, but Israeli dependence on the water in the occupied territories means that any return of control to the Arabs would be seen as a direct threat to Israeli development.

c) Jordan:

Like both Israel and the occupied territories, Jordan also faces serious water shortages. Again, data for Jordan's water demand and supply are not readily accessible, but total consumption has been estimated to be approximately 870 MCM annually (Frey and Naff, 1985).

To meet this demand, Jordan is already using almost all of the water available to it, and this situation is expected to worsen by the end of the century, when demand is expected to reach 1000 MCM, exceeding supply by 20%. With a population growth rate of 3.7% annually (Tables 3.1 and 3.2, and Figures A.3.1 and A.3.2), the third highest in the world, Jordan's population will double early in the next century (Myers, 1989). Food production remains low and increases in agricultural output will require more water. In addition, the country is also interested in developing its industrial sector, which will create an additional demand for water. Therefore, Jordan is facing an ever-increasing deficit in water supply, and if no solutions to the water problem are found, the standard of living in the country will drop or development will be curtailed (Naff and Matson, 1984). Jordan is also interested in water resource planning, and the nation is attempting to increase its supply through more re-use, diversion of agricultural water to industrial and municipal needs, and development of groundwater resources through continued exploration and deeper drilling (Taubenblatt, 1988). If population and industry continue to grow, however, additional sources will be needed.

As a result, Jordan is attempting to initiate joint water projects with Syria. Since the late 1970s, when relations between Jordan and Syria deteriorated, the acuteness of the water problem has led to new cooperation between the two countries (Taubenblatt, 1988). In 1987, Jordan and Syria ratified an agreement allowing the construction of the Unity Dam which is expected to have a storage capacity of 220 MCM per year. Officials in both countries claim that such an effort will help to regulate the flow of the Yarmuk, provide Syria with power, and increase the supply of water to Jordan for agriculture (Chesnoff, 1988). Even this agreement, however, poses difficulties; contrary to the terms of the agreement, Syria appears to be interested in

setting up a series of medium and small dams to divert much of the Yarmuk's water, and for Jordan this would mean losing significant amounts of water needed for agriculture and municipal and industrial purposes in the urban centres (Starr and Stoll, 1988). Also, Syrian plans to develop the Yarmuk higher upstream than expected would give Damascus control of Jordan's economy, (Chesnoff, 1988). Because of these problems, there is once again a possibility of heightened tensions between Syria and Jordan once again.

d) Security in the Region:

With respect to water agreements, the situation in the Jordan River basin in general has been similar to that shown in the example of Syria and Jordan. The basin is well suited to integrated development, but any agreements that have been tried so far have failed (Anderson, 1988). Since 1947, attempts to reach some level of cooperation have been blocked by the water question. As Cooley (1984) notes:

> while the need for a rational, overall water-sharing scheme steadily grows more apparent, it seems less attainable, as water issues are aggravated by political tensions and by the fact that, while its neighbours' consumptions are rapidly rising, Israel still consumes roughly five times as much water per capita as each of its less industrialized and less intensively farmed neighbours. p. 3.

In 1964, an Arab summit meeting resolved to divert the headwaters of the Jordan's tributaries outside of Israel. When these attempts were made, there were open clashes between Israel and the Arabs, and since that time the water question has effectively been militarized (Anderson, 1988). The basin has been the scene of international conflict before, and it remains a likely place for violence in the future.

For decades, all Jordan River riparian states, as well as the United States and the United Nations, have attempted to negotiate an acceptable regional plan for the distribution and development of the Jordan waters (Calleigh, 1983). The most comprehensive plan for cooperative use of the Jordan suggested to date was the Johnstone Plan in the early 1950s. This proposal, however, like all others before and after it, was derailed by political intransigence and distrust between the riparian states, and each nation has continued to follow its own policies, often to the detriment of other nations (Beaumont et. al., 1988). The political difficulties in the region are immense, as the Jordan River divides not only individual Arab states with vastly different plans and ideologies, but it also divides the Arab world from Israel (Anderson, 1988).

Perhaps the most important hope for the future of the region is technological improvement. This avenue is currently being given a great deal of attention, and Jordan and Syria could benefit from research regarding efficient water use and management ideas carried out in Israel (Frey and Naff, 1985). Such information is not readily transferred, however, and although technology may be able to address some of the water problems, political factors appear more important. Cooperation between the riparian states is essential for the resolution of the water crisis, but it is doubtful whether the political leadership in Jordan and Israel will be able to resolve these problems successfully in the context of the greater Middle East conflict. The issue of water scarcity in the area is very complicated, and made much more difficult by the question of the Palestinians in the Occupied Territories. As well, because Jordan and Syria have strong ties to other Middle Eastern states, there is a good chance that any confrontation they might have with Israel would involve much of the larger region. The potential for renewed water-based conflict in the Jordan Basin, then, is great.

2. The Litani River

The question of security as it relates to the Litani River is linked to, but somewhat different from the situation involving the Jordan. The most distinguishing feature is that the Litani lies entirely within the boundaries of what is internationally recognized as the borders of Lebanon. Also, more rain falls over the Litani than any other river in the region, and its flow is approximately 700 MCM annually. Although there is little data available regarding the water quality of the river, it is believed that the Litani is a high quality source, with salinity estimated at about 220 ppm, making it usable for irrigation of almost any crop (Naff and Matson, 1984). The quality of the water depends largely on future development patterns in the country, and if agricultural production grows substantially the salinity will most probably increase as well. The government of Lebanon places great priority on development of the river for the generation of electricity, and the construction of irrigation systems has largely been delayed because hydroelectric facilities are more profitable (Naff and Matson, 1984). If the political situation in Lebanon stabilizes, agricultural, industrial and population demands could place more pressure on water resources. Given current conditions, however, the continued high quality of the Litani will probably be maintained and demand will not reach unmanageable levels for some time (Naff and Matson, 1984). Still, Lebanon remains dependent on the Litani as a source of water, and if the state is to prosper it must continue to develop and harness the resources of the river.

The most persistent threat to Lebanon's rights over the Litani River has involved Israel, and there have long been discussions within the Israeli government regarding diversion of Litani water into Israel. The Litani closely approaches the headwaters of the Jordan River and the traditional Israeli position has been that the Litani is part of that system (Naff and Matson,

1984). In the past, the Israeli government was apparently interested in use of the Litani if it could be secured through Lebanese agreement. Now, however, with the decline of water resources in their own country, Israel may seriously consider other options to divert the Litani regardless of legalities or international repercussions.

Many believe that water had a key role in the 1982 invasion of Lebanon by Israel. Israel actually gains relatively little in terms of its entire water budget from the area it occupies in southern Lebanon, but it does give the state control of all sources of the upper Jordan and may allow the Israelis to divert water from the Litani through the use of a tunnel system which could increase Israeli supplies by as much as 500 MCM annually (Anderson, 1988). The official Israeli intention to occupy a security zone in southern Lebanon has been interpreted throughout the Arab region as a scheme to divert the Litani, and this strengthened Arab convictions that capturing and retaining control of the river is the long-term Israeli goal (Cooley, 1984). This claim has been strongly denied by the Israeli government, but the fact remains that the Litani is the only additional surface source of water available to Israel (Anderson, 1988). Israel justifies its invasion of Lebanon by claiming that, in light of the presence of the PLO in the area, it was an act of self defense. According to the "International Commission to Enquire into Reported Violations of International Law by Israel During its Invasion of Lebanon" (1983), however, there were more fundamental objectives associated with the invasion. Their report claims that:

> Israel harboured certain territorial aspirations toward Lebanon, the most significant of which may have been its intention to obtain access to or possibly control over the waters of the Litani River, the major sweet water source in Lebanon, which makes the southern Beka'a Valley the richest agricultural area in Lebanon. p 12.

The Commission further notes that Israeli Cabinet Minister Ne'eman advocates remaining in southern Lebanon and controlling the country up to north of the Litani, and other Israeli officials have suggested aiding in the installation of a Christian regime in Lebanon allied with Israel so that the territory from the Litani southward can be annexed to Israel. Naff and Matson (1984) also point out that some people in Israel still believe that Litani water is the only source which will allow Israel to maintain present consumption rates and allow the government to avoid the difficult choices accompanying conservation measures.

The invasion of southern Lebanon could be similar to the acquisition of territory in the 1967 war; Israel may have gained territory for political purposes, but found that exploiting the newly available resources led to a dependence which made withdrawal very difficult (Calleigh, 1983). What is clear, however, is that Israel's invasion of Lebanon has strengthened suspicion among its Arab neighbours regarding its need for increased water resources and that, with the political turmoil existing in Lebanon, there is little chance of the country reaching an agreement with Israel regarding the Litani. Left unaddressed, though, this issue will continue to disrupt the political situation in Lebanon. Israel remains interested in water from the Litani and, according to Naff and Matson (1984), may take "extreme measures" should any Arab actions threaten the possibility of future use. Also, Syria will most likely continue to be involved in the region without guarantees that its needs will be protected, as the headwaters of the Orontes River, which provides drinking water and hydroelectric power, lie within Lebanese borders (Cooley, 1984). Thus, the Litani water resources may have had a key role in disturbances within Lebanon in the past, and there is further indication that the river will continue to add to the insecurity of the troubled nation for years to come.

3. The Nile River

Like the Jordan, the Nile, the longest river in the world, flows through a number of states, all of which make use of it as a major water source. Egypt currently makes the most use of the Nile and, to a large extent, controls the river and the politics of the basin. However, the water needs of the two main upstream states, Ethiopia and Sudan, are currently growing, and pressure on the water resource is likely to increase. At present, the quality of the Nile is quite good in terms of salinity, with levels at approximately 220 parts per million. But the riparian states are undergoing agricultural expansion and are heavily dependent on fertilizers and pesticides and, as a result, there is much concern that water quality could well be a problem even before scarcity becomes acute (Naff and Matson, 1984). This has become even more of a concern since Egypt claims to have knowledge of Israeli engineers working with Ethiopia to design new irrigation systems (Economist, 1990). Again, this decline in the quality and quantity of water available in the Nile basin could lead to conflict between the riparian states.

a. Egypt:

Reliable data regarding Egyptian water use and availability is sparse. The Egyptian government and the World Bank recently undertook a comprehensive study of the country's resources, but much of the information remains restricted. Waterbury (1982) estimates that by 1990 Egypt's water use will approach 72 billion cubic meters (BCM) annually, while the available supply will only equal 67.1 to 68.9 BCM per year (cited in Beaumont, 1989; Krishna, 1988; Starr and Stoll, 1988). Thus, while the Egyptian water plan claims that there is ample water for its new and ambitious irrigation projects, experience has often shown that government

statistics tend to be overly optimistic, and Waterbury's study suggests about an annual four BCM deficit by the beginning of the next century (Beaumont, 1989).

One of the main reasons for the increase in demand is the rapid population growth in the country. The presently accelerating population increase, if sustained, means that there could be approximately 70 million people in the country by the end of the century (Beaumont et. al., 1988) (Tables 3.1 and 3.2). With limited water resources, population growth could pose serious difficulties, as water scarcity is already a serious threat. The Aswan High Dam, built in the 1950s, was expected to expand water storage capacity, extend the cultivated area of Egypt and provide flood protection by lowering the water table. The success of the project is difficult to assess; the Egyptians see it as a symbol of progress, but critics of the dam point out that the dam has: i) led to sediment deposition and accumulation, making the water more erosive; ii) decreased the supply of nutrients in the water, damaging the Nile fishing industry; and iii) increased the spread of disease (Beaumont, 1985). Clear, however, is the fact that the high dam has not solved the basic problem of inadequate supply and increasing pressure on water resources. The 1987 Middle East Review indicates that water in Lake Nasser is at low levels, which is having a negative effect on fish breeding and power generation, and officials were discussing the possibility of water rationing in 1988 if supplies did not increase.

With the waters of the Nile being used to the maximum extent, the Egyptian government has begun to consider proposals to increase the efficiency of water use. Some progress has been made in the development of recycling procedures and additional sources of groundwater have been found, but these advances have so far yielded comparatively modest amounts (Anderson, 1988). As well, agricultural requirements are also growing with populations levels and irrigation

expansion is needed to combat food deficits. Present systems, though, are inefficient and contribute significantly to wastage (Middle East Review, 1987). As a result, there have been attempts to make use of more sophisticated application systems. This technology, however, is expensive to install and maintain; estimates of the expense of introducing these methods in Egypt suggest it would cost approximately $9 600 US per hectare (Adams and Holt, 1985, as cited in Beaumont, 1989). Thus, while demand continues to increase, the potential for expansion of supply remains limited and, as Beaumont et. al. (1988) state:

> the continued rapid population growth, the need to resettle people in the desert areas to relieve some of the desperate problems of urbanization, and the utilization of most of the extra water generated by the building of the High Dam has made a review of the potential utilization of the Nile waters necessary once more. It is clear that Egypt has little more opportunity for increasing water supplies within its own boundaries and this has resulted in new debate about boundaries and in new debate about the international hydropolitics of the whole Nile basin. p. 528.

b. Relations Between the Riparian States:

Despite numerous riparians in the Nile Basin and the water resource problems of those countries, the Nile region has still escaped much of the conflict characteristic of other water systems. Egypt had virtually exclusive control of the Nile until the end of the nineteenth century, as the nation has historically been the most developed, the other riparian states had alternate water sources, and no shortages existed to produce conflict (Naff and Matson, 1984). Tensions, however, began to arise this century when the needs of Egypt and the other users grew, and a series of management plans were developed.

Perhaps the most important factor in the development of the Nile is Egypt's relationship with Sudan. Cooperation between the two states has been demonstrated in the past, but the Aswan High Dam project raised questions regarding conflict issues between Egypt and Sudan, as the project was intended to keep a reservoir of water inside Egypt. Egypt claimed they had "primary needs" in the region because, unlike Sudan, they had no alternate sources of water and because the Sudanese population was smaller. An agreement was reached between the two nations in 1959, granting Egypt water use rights equalling 48 BCM annually and Sudan 18.5 BCM (Krishna, 1988). However, while in the early 1980s Sudan was using 15 - 16 BCM per annum from the Nile, a deficit in water resources is now predicted (Anderson, 1988). The population in Sudan is growing rapidly, and increased desertification and land degradation have become serious problems. As a result, the country plans to introduce new irrigation systems which may raise demand by as much as 10 BCM yearly (Beaumont, 1989). If the Sudanese economy does not improve, such development will be slow in taking place, but demand increases will likely require revision of the 1959 agreement as Egypt and Sudan will be forced to compete for a greater share of Nile water in the coming decades.

Also important in this situation is the role of Ethiopia, often called the "great unknown" of the region. Waterbury (in Starr and Stoll, 1988) estimates that Ethiopia is the source of greater than 82% of the Nile's water, so the development plans of the country could have great impacts on Egypt and Sudan. Ethiopia currently exports approximately 100 BCM of water to its neighbours annually (Krishna, 1988). However, with its own rapid population growth and increasing food demands, Ethiopia will also require more water in coming years. As well, erosion of soil in the country is great, and the effects of desertification must also be addressed.

As these problems worsen and Ethiopia requires more water, the government is contemplating plans which would reduce discharge of the Blue Nile to Sudan and Egypt by as much as four BCM per year, indicating a potential for trouble in the region (Timberlake and Tinker, 1985). Already, in the early 1980s, conflict arose between Ethiopia and Egypt, as Ethiopia reportedly charged Egypt with misusing its share of the Nile by diverting it into the Sinai where it was vulnerable to Israeli use. Egypt responded by warning that:

> If Ethiopia takes any action to block our right to the Nile water, there will be no alternative for us but to use force. Tampering with the rights of a nation to water is tampering with its life and a decision to go to war on this score is indisputable in the international community (Krishna, 1988, p. 34).

Ethiopia, however, maintains the sovereign right of any nation to develop any water resources within its borders (Timberlake and Tinker, 1985) and, as an Ethiopian official stated, "Ethiopia simply does not acknowledge any existing treaty or other obligation preventing it from freely disposing of the Nile waters on its territory" (Krishna, 1988). It is likely, then, that Ethiopia will remain prominent in Egyptian foreign affairs, and any future developments involving water will be anxiously monitored by the Egyptians.

In the Nile Basin, then, with a number of riparians sharing the same source of water, relations remain convoluted. To a large extent, the prospect for conflict or cooperation in the region still depends on the success Egypt achieves in maintaining its role as the principle political and military actor, in reversing its explosive population growth and in attaining adequate water supplies to meet increasing demand (Naff and Matson, 1984). The 1959 agreement with Sudan is currently the only regulatory instrument, and at this time the upstream riparians still

lack the sufficient technical and military power which would be necessary to alter present conditions. However, this situation may be changing, and as Naff and Matson (1984) state:

> Egypt, vulnerable both in terms of quality and quantity of the Nile's waters, has one overriding concern: continued control of the Nile. Until recently, Cairo's control of the Nile through power and large-scale projects has been unchallenged. Now, owing to a proliferation of small upstream projects, Egypt faces the possibility that its technological dominance among the riparians and its controlling political power will decline while its vulnerability and dependence as a downstream user increase p. 140.

The possibility of future conflict is quite real, and Egypt's plans to reclaim land in the Sinai desert by diverting Nile waters there, and possibly to send Nile water into Jerusalem as an aid to solution of the Palestinian problem, complicate the already tense situation (Krishna, 1988). Another existing problem that could pose serious security threats in the future is the number of environmental refugees in upper Nile states, a problem that could easily be exacerbated with a reduced water supply (discussed below). A basin-wide approach would be ideal in the development of the Nile system, and in 1986 the United Nations Development Program workshop for the Nile basin countries took preliminary steps toward achieving this goal (Starr and Stoll, 1988). However, much more work is needed, and the political situation in the region makes the necessary cooperation between the riparian states unlikely. Instead, each nation will probably continue on its own development path, making competition for Nile water greater and increasing conflict in the region.

IV. AGRICULTURAL PRODUCTION

A. Introduction

The basic non-living resource is land, which supports almost all human activities, one of the most important of which is food production. As population increases, however, land is often degraded through soil erosion and nutrient depletion, and the amount of arable land available diminishes (Westing, 1988). This global trend is evident in the Middle East, as the region is faces an increasing food production deficit. Physical factors limiting agricultural expansion in the region are great: climatic conditions and soils are not conducive to food production; cultivable land amounts to only a small fraction of total land mass and the rest is desert, swamp or mountain; and seasonal temperature variations are quite wide. As noted previously, the main environmental constraint in the Middle East is a lack of water. In addition to these natural limitations, soil erosion is an increasing problem, which is associated with the removal of vegetative cover, overgrazing and the monoculture of cereals (Beaumont, 1985). In the past humans have been able to overcome environmental constraints in the region and develop stable agricultural production, but a dangerous degradation of resources is increasing as human activities stress the already fragile ecology.

Agriculture, however, is still of considerable importance in the Middle East, and it generally employs much of the labour force and provides the raw materials which are necessary for manufacturing (Beaumont et. al., 1988). In fact, the contemporary Middle East appears to have averted some of the worst consequences of drought and calamities, and recently the

countries in the region all had close to or better than the per capita daily energy requirements estimated by the Food and Agricultural Organization (Weinbaum, 1982) (Table 4.1). The region has been unable to keep pace with increases in demand due to explosive population growth, however. In the 1970s, the average population growth rate was 2.9%, while the regional increase in food production was only slightly higher, between 3 and 4% (Weinbaum, 1982) (see Table 4.2 and Figure 4.1). Stimulated by population growth and policies aimed at raising nutritional levels, increases in the demand for food have occurred, but innovations aimed at increasing agricultural output have met with only limited success (McLachlan, 1985). As a result, by the year 2000 agricultural production is expected to be at 148% of the 1970 level, but demand will have risen by 227% (Weinbaum, 1982). Governments are uneasy about any dependency on food imports, since it usually entails heavy financial burdens, a threat to development, and potential strategic vulnerability. Although self-sufficiency in agricultural production is the goal of all national leaders, Middle East states are currently being forced to buy from international markets (Allan, 1985).

As a result, there is a great deal of interest throughout the Middle East in increasing agricultural output. There is potential for growth if water resources for irrigation become more readily available, either through increased efficiency or more re-use, and there has been a great deal of effort expended to accomplish this goal. Existing irrigation is making some contribution to increased production, and the technology needed to irrigate new areas is available. However, extension of the present system would be very expensive, would require a great capital investment, and the escalating costs of construction and maintenance would not necessarily be offset by rising agricultural prices (Beaumont, 1985). Rates of reclamation of new irrigated land

have tended to be negligible, even in those states where large sums of money have been spent on development, and irrigation may have to decrease as water is increasingly

Table 4.1. Food consumption (calories/capita/day), 1961 - 1986.

FOOD CONSUMPTION Calories/Capita/Day						
	1961-63	1964-66	1969-71	1974-76	1979-81	1984-86
World	2296	2409	2444	2506	2600	2694
Africa	2093	2151	2178	2242	2327	2299
Egypt	2307	2437	2467	2692	3031	3313
Ethiopia		1782	2027	1822		
Sudan	1853	1858	2171	2142	2379	2074
Asia	1899	2044	2094	2171	2320	2485
Israel	2795	2803	3010	3063	2976	3038
Jordan		2299	2374	2366	2900	
Lebanon	2362	2450	2477	2563		
Syria		2198	2391	2498	2945	3259

Source: FAO, 1988.

diverted to urban complexes (McLachlan, 1985). Also, the environmental costs of irrigation are becoming more apparent. In much of the region, soils are characterized by low water-holding capacity and a tendency to deteriorate structurally when irrigated, and the loss of irrigation water to groundwater reserves creates problems of waterlogging and salinization (Heathcote, 1983).

Table 4.2. Agricultural production indices (1979-1980 = 100).

AGRICULTURAL PRODUCTION INDICES (1979-80 = 100)					
	1970	1975	1980	1985	1987
World	79.3	89.1	99.1	114.3	115.0
Africa	79.3	93.4	100.5	112.6	115.5
Egypt	78.4	92.1	100.1	116.9	124.6
Ethiopia	80.2	86.5	98.8	97.1	102.3
Sudan	79.3	93.9	96.8	118.6	104.3
Asia	80.2	86.4	99.4	112.5	125.1
Israel	77.0	94.4	98.2	124.2	126.5
Jordan	63.5	60.8	11.4	143.5	145.5
Lebanon	78.6	77.1	112.4	118.5	117.1
Syria	71.4	68.9	106.5	110.2	113.8

Source: UN Food and Agricultural Organization, Agriculture Statistics, 1988.

With a growing awareness that irrigation is not the simple answer hoped for, other solutions are being considered. Technological developments, however, do not appear to be sufficient in the Middle East. As McLachlan (1984) states:

> if physical developments of irrigation schemes, crop innovations or the introduction of the green revolution have failed to produce a brave new world for agriculture in the Middle East and have left the region among the least successful in the world vis a vis productivity and growth rates in agriculture, it might be wondered whether changes to the agrarian structure might not be more rewarding (p. 44).

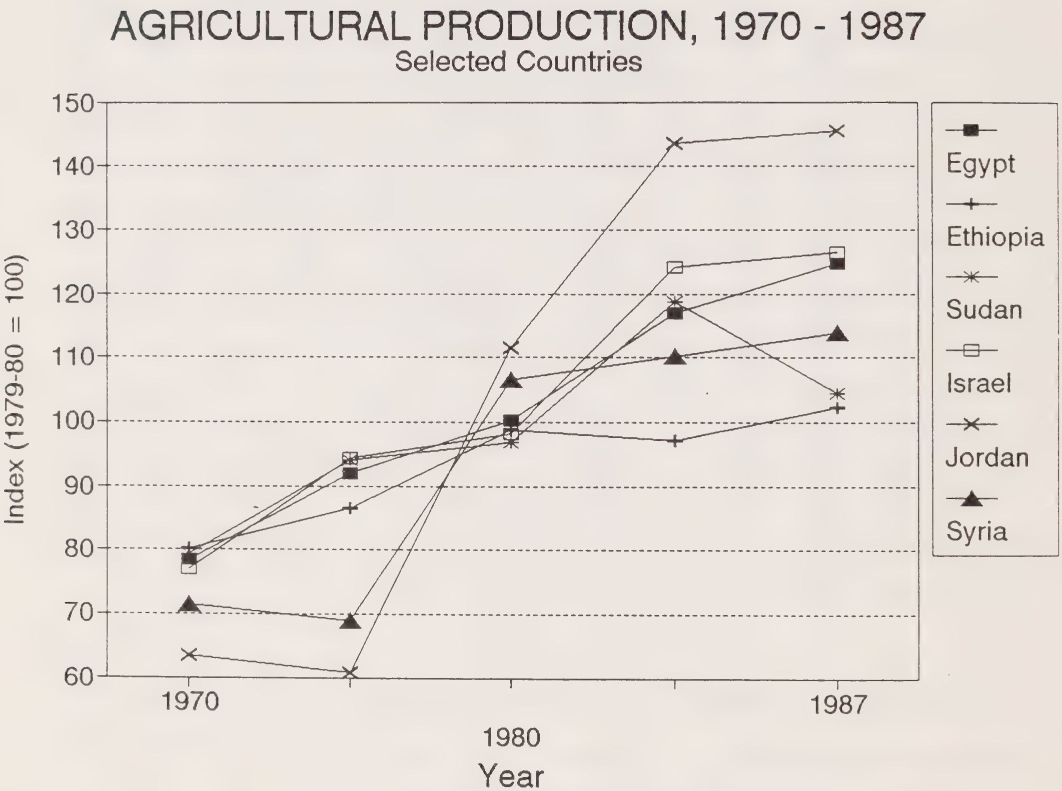

Figure 4.1. Agricultural production, 1970 - 1987, selected Middle East Countries.

In spite of government promises that agriculture would be protected as a source of food and employment, its status has generally declined and the best human and technical resources have been allocated to other activities. Most states are more interested in the development of industry and manufacturing, and wages in agriculture are lagging so far behind other sectors that only the very young, the very old and the unemployable are involved in food production (McLachlan, 1985). Land reform has largely been ineffective, and there has been a general shift in population to urban settings, meaning that there is less labour for the agricultural sector (Beaumont et. al. 1988). As a result of these trends, the prospects for increased food production and progress for agricultural development in the future is limited.

Threats to food supplies have been the cause of past frictions and may cause further trouble as population growth increases pressure on agricultural systems. Food is a potential political tool when goods are scarce and a state is dependent on other nations for its food needs (Wallensteen, 1986). Conditions of food deficit can also lead to political unrest, rioting and even civil war (Westing, 1986). Indeed, in many countries, declines in the natural resource base that supports agricultural production have led to rising prices for food and ultimately to shortages, and these in turn have triggered violence (Myers, 1986). For example, disarray in Iran's agricultural sector increased the number of those disaffected with disparities in national incomes and lifestyles, and in 1978 they challenged the Shah's political order (Timberlake and Tinker, 1984). Other examples include the 1985 violent overthrow of the regime in Sudan which has been attributed in large measure to food shortages and accompanying high prices, the 1974 overthrow of the regime in Ethiopia which was in part the result of inadequate food supplies, and rioting in Jordan and Egypt involving damage, injuries and deaths, and which was

triggered by increases in food prices (Timberlake and Tinker, 1984; Westing, 1988; Satloff, 1990). Thus, a great deal of violence in the region in recent years has been associated with agriculture and food shortages.

B. The River Basins

1. The Jordan River

a) Israel and the Occupied Territories

At the beginning of the Second World War, agricultural production in Israel expanded rapidly in response to the growing needs of Europe. Since that time, agriculture has remained the most important sector in the Israeli economy, and a major challenge has been to absorb the mass migration of people into the country without a decline in the average standard of living (Porath, 1986). Currently, Israel is largely self sufficient in food production, meeting domestic demand for vegetables, fruit, milk, eggs and poultry (Middle East Review, 1990). Agriculture represents 7.5% of the nation's gross domestic product, with production of cash crops and export goods more than financing the needed imports of some cereals and animal feeds (Middle East Economic Handbook, 1986). However, the production of one of the most important components of the economy, citrus fruits, is showing some decline and total exports were down in 1988 (Middle East Review, 1990). The nation's water shortage has serious implications for agricultural development, and problems are beginning to emerge as a result of this problem. New techniques are being studied to increase the water available for food production, such as cloud seeding and waste water reclamation, but these have questionable short-term value. Thus, while food security is not now a pressing issue, the agricultural situation in Israel is not very

stable and unless the water problem is solved more declines in food production are expected in the future.

Competition between the Palestinian farmers and Israeli settlers in the occupied territories is also a significant issue. Agriculture is the backbone of the West Bank and Gaza Strip, contributing more to gross national product and employing more of the labour force than any other economic sector (Gharaibeh, 1984). But of the West Bank's approximate 5.8 million dunams of land, only about 2 million are cultivable (Kahan, 1987). Drought conditions in the 1980s and the poor distribution of rain throughout the period has resulted in marginal tracts of land being abandoned and a decrease in the overall area cultivated. The West Bank economy, based largely on rainfed agriculture, is particularly vulnerable to drought conditions, and since 1980 adverse rainfall conditions have led to cultivation of fewer crops, lower production levels and a period of stagnation in the agricultural sector (Kahan, 1987). After 1980 economic development in both Jordan and Israel slowed, with a direct effect on the West Bank situation; there was less demand for local produce, rising unemployment, and by the early 1980s GNP from agriculture was declining by an annual rate of 8 percent from the 1983 - 84 period.

With the problems in the agricultural sector, tensions between Israel and the Occupied Territories have increased. The Israeli government has imposed policies aimed at enhancing its own farming sector, using restrictions when they can lead to advantages (Kahan, 1987). Palestinians are required to obtain permits in order to sell their products in Israeli markets or to export them to Europe. In addition, the strict control of Arab farmers' use of water means greater advantages for the Israelis. With food production in Israel and the West Bank vulnerable

to future problems, it is not altogether surprising that there is conflict between Israeli and Palestinian farmers, and a great deal of resentment as a result of these restrictions.

b) Jordan

There is a widening gap between food production and demand in Jordan. The country has limited land and human resources available for agricultural development. Shortages of water and poor soil conditions are predominant problems, and most available river reservoirs are utilized by expensive irrigation plants (Weiss, 1987). Only 9% of the total area of Jordan receives greater than 200 mm of rainfall per year, yet approximately 93 percent of the total cultivable area is dependent on natural rainfall (Qasem and Mitchell, 1986). In these rain-fed areas, a desire to increase production has led to cultivation beyond the limits of sustainability, resulting in considerable erosion and widely fluctuating crop yields (Beaumont, 1989). The loss of the West Bank in the 1967 war cost Jordan land which had helped feed many of its people and had accounted for 80% of its fruit and 45 percent of its vegetable production for export (Cooley, 1984). As well, more of Jordan's land is currently being lost, due to the deforestation of the uplands for timber and firewood, the widespread monoculture of cereals, and the overgrazing of pasture land by sheep and goats. These factors have increased environmental degradation in the fragile region, and measures which have been taken to stem erosion have been only moderately successful (Beaumont, 1989). The cost of reclaiming land is prohibitively high, and capital-output ratios for such investments exceed those for possible industrial development (Weiss, 1987). As well, population growth, both natural and due to an influx of Palestinian refugees after 1967, and increased urbanization have made vast amounts of land unavailable for

cultivation (Qasem and Mitchell, 1986). As a result, agriculture accounted for only 6.7% of the country's gross domestic product in 1983, and in recent years Jordan has relied heavily on food imports at a cost of US $439 million in 1984 (Middle East Economic Handbook, 1986).

Because of the importance of agricultural independence, the Jordanian government has stressed the need to increase domestic grain production (Mitchell, 1986). The 1981 - 85 Five Year Plan was designed to provide food security by enabling the government to meet the food requirements of its citizens at all times and in all regions (Abuirmeileh, 1987). This plan represents a commitment to balanced development of agricultural as well as other sectors of the economy, and includes: i) development of agriculture within a framework of rural development; ii) increasing participation through the establishment of cooperatives and popular organizations; iii) intensification of research into the raising of productivity and the introduction of modern techniques; iv) the integration of animal and plant production; v) creation of strategic stocks of basic foodstuffs; and vi) the production of commodities where Jordan enjoys relative advantage (Abuirmeileh, 1987). The Ministry of Supply also offers high prices for locally grown wheat in an attempt to increase the domestic supply. Also, the Jordanian Agricultural Extension Service has helped farmers experiment with new crops, fertilizers and pesticides, and has provided cash loans and incentive grants (Mitchell, 1986; Beaumont et. al., 1988). The East Ghor Canal project has also had tremendous impact on the agricultural sector, and the accompanying Canal Law appropriated land within the area of the scheme, compensating landlords and allocating land in more efficient units than previous very large and very small farm structures (Beaumont, 1989).

In spite of government attempts to improve the agricultural situation, however, basic problems still remain. Government agencies assigned to implement new programs are generally weak and inefficient, and agricultural support services are not usually of high standard (Abuirmeileh, 1987). The most difficult issues have not been adequately addressed; water scarcity is still the most limiting factor, and population pressure continues to increase. Also, damage occurring as a consequence of war has set back the agricultural program in Jordan (Anderson, 1988). The recent stagnation in farming has been accompanied by a population drift towards the cities where manufacturing, commerce and construction offer greater employment opportunities, and those who tend to migrate are young, active and mobile, leaving behind an aging population not favourable to new ideas or new technology (Qasem and Mitchell, 1986). While the prime objective of the Jordanian government is to feed its people, the actual food situation has deteriorated, leading to a growth of imports and a drain on valuable foreign currency reserves (Beaumont, et. al., 1988). There is little possibility that in the near future Jordan will be self sufficient in food production (Beaumont et al., 1988). Instead, it seems reasonable that the situation may deteriorate further.

Agricultural problems in Jordan, like those in Israel, have political implications for the region. The Jordanian government, attempting to foster domestic production, limits the export of fruits and vegetables into the East Bank, and has imposed an Arab boycott of Israeli goods. With production problems in both Israel and the Occupied Territories, these policies make the current difficult situation even more tense (Kahan, 1987).

c) Syria

Syria, with relatively favourable arable land per person, has a high potential for agricultural expansion, but increased production depends on its access to the shared river system (Weinbaum, 1982). Currently, only 9% of the total cultivated farm land is irrigated, resulting in a dependence on unpredictable rain-fed agriculture (Middle East Economic Handbook, 1986). With one of the highest population growth rates in the world, 3.7% annually (see Table 3.2), Syria will need to establish a more stable agricultural base to ensure that future food needs are met (Middle East Review, 1990). As agricultural deficits in Jordan riparian states increase, then, not only could tensions in regard to markets and trade grow, but the increased need for already scarce water will also raise the likelihood of violent conflict.

2. The Litani River

Compared to its neighbours, Lebanon is favoured by a mild climate and relatively rich soil. However, only 38% of its land is arable and, in the absence of more irrigation, cultivation is restricted to approximately 22 percent of the land (Who's Who in Lebanon, 1986). Agriculture is an important sector of Lebanon's economy, and the country is a large exporter of fruits and vegetables. Due to the political situation, data regarding food production in the country is generally unavailable. Security issues in the region, though, do appear to be threatening food production. Most of the irrigated agricultural land is in the Syrian controlled Beka'a Valley, and the presence of Syrian troops disrupts production in the area. Also, Syria traditionally received almost half of Lebanon's exports of fruit, but because of war in the region

Syria shut down the highway (recently reopened) linking the two nations and transportation of goods has been difficult (Starr, 1984). Saudi Arabia initiated a boycott of Lebanese products after the Israeli invasion of 1982, and the agricultural situation in Lebanon has been greatly effected by political unrest in the country.

3. The Nile River

Egypt's population is now over 50 million, and increasing food production to a level which can support that number of people is becoming a primary concern (Naff and Matson, 1984). The Nile Valley supports greater than 95% of Egypt's population and, with alluvial soils, continuous warmth all year for continuous crop growth, and no extremes of hot and cold, the environment is very conducive to agriculture (Beaumont, et. al. 1988). However, with less than 5% of the country's land settled and cultivated, population density is already so great that land holdings are often too small to yield a reasonable standard of living. Both cultivated area per capita and crop area per capita are declining and the task of feeding its people will certainly be formidable (Beaumont, 1985) as Egypt's population will reach 60 million by the year 2000. An even bigger problem is the increasing rural-urban migration which has the effect of converting prime agricultural land on the urban fringe to non-agricultural uses. This expansion of settlements along the banks of the river forces agriculture into areas where the soil is less fertile, irrigation costs are higher, and there is greater potential for water wastage (Beaumont, 1985). In 1980, Egypt was losing approximately 20,000 hectares per year to urban sprawl (Weinbaum, 1982). The country is still very inefficient in water use, using unlined and poorly maintained canals and neglecting re-use of irrigation water; misuse of water resources has, in

turn, ruined previously productive land (Naff and Matson, 1984). As a result, water will be a severe limiting factor in agricultural expansion in the future. As human and cattle populations increase, land degradation poses a further threat, and human activities, pressure on forests, soil and land have made the region's ecosystem less resilient (Jacobsen, 1988).

As a result of these problems, Egypt's food production is not keeping pace with increases in demand and its food deficit is growing. By 1987, Egypt was importing greater than half of its food requirements. By 1985, it was estimated that food production was rising at about 3.5% annually, while demand was increasing by about 5% per year (Beaumont, et al., 1988). Egypt has moved from a surplus trade balance of approximately US $300 million in the mid 1970s to a deficit of almost 3 billion dollars in the 1980s, and trying to arrest this accelerating increase has become a national priority (Middle East Review, 1987). Official strategies to achieve this goal include improved efficiency in land and water use, expanding use of fertilizers and mechanization, and encouragement of foreign investment in Egyptian agriculture. Experiences to date, however, have not been encouraging, and net additions to the cultivated areas have been small. Early optimism regarding irrigation and dryland reclamation schemes has not been matched by performance, and as the demand for water from industry, power generation and domestic needs increases, water available for agriculture will diminish in quantity and quality (Adams and Holt, 1985; McLachlan, 1985). Thus, while the government of Egypt is concerned about the increasing dependence on imported food products, there is little indication that in the near future the problem of the food deficit will be solved. Instead, development of agriculture in the country will depend on appropriate irrigation methods, heavy capital investment and cooperation throughout the river basin region.

Other riparian states in the area are also facing difficulties in agricultural development. Of a total area of 2.5 million square km in Sudan, almost half is available for agriculture (Naff and Matson, 1984). Approximately 80% of the labour force is involved in agriculture in Sudan, and one third of its GDP is generated by this sector (Beaumont, 1989). A rapidly increasing population is placing great pressure on land resources, and desertification and degradation have become severe problems. Sudan does have great potential for expansion of cultivation and new regions could be opened up to farming. This goal, however, would require transformation of the entire system of traditional farming and building infrastructure which would require large amounts of capital (Weinbaum, 1982), unlikely with the present armed conflict in the country. The critical factor in the future of agriculture in Sudan is use of the Nile and, thus, its relations with Egypt.

Similarly, Ethiopia in the 1970s was losing approximately one billion tonnes of soil each year due to desertification and erosion. By 1982, almost one half of Ethiopia's irrigated croplands were suffering from salinization, and about 10% of its annual agricultural production was being lost due to declining soil fertility (Myers, 1986). By 1986 the country was forced to import 121 million tonnes of cereal grains (55% of its food needs) at a cost of US $4.1 billion (Myers, 1989). Like the other nations of the Nile region and, indeed, throughout the Middle East, Ethiopia is facing increasing demand as a result of population growth, while its production capability is limited by water scarcities. It would be ideal for the riparian states to cooperate in a joint venture, as Egypt controls the majority of water resources and the other nations possess more available land for future development (Beaumont, 1989). The political situation, however, makes any agreement unlikely, and it is more probable that each will continue with

its own projects in spite of their lack of success. As a result, food deficits in Egypt, Sudan and Ethiopia will apparently grow, increasing the chance of political unrest within the countries and making tensions regarding exploitation of the Nile and other resources worse.

V. ENVIRONMENTAL REFUGEES

A recent area of concern relating to environment and security is an understanding of the potential for displaced people to cause conflict. The U.N. High Commissioner for Refugees (Stoltenberg, 1990), points out that while there is a general consensus on the need for a global environmental strategy, and a new recognition that security has social and economic, as well as military dimensions, it is still of primary importance that the refugee issue begin to appear on the international agenda. Never in history have there been so many refugees from so many countries; most sources place the number of refugees worldwide at between 10 and 12 million (Loescher and Monahan, 1989; Rogge, 1987; Smyser, 1987). A United Nations committee has been established to study the refugee dilemma and provide aid for displaced people, and many humanitarian organizations have worked diligently to ease the suffering of refugees worldwide. However, refugees have been largely ignored in the past, and often have been viewed as tragic but irrelevant by-products of international political processes. This situation is changing somewhat, and refugees are acquiring more significance as the interdependence of political systems is increasingly recognized. Loescher (1989) notes that it is becoming clear that refugee movements are not simply unique or isolated events marginal to the central issues of war and peace, and there must be a serious consideration of refugee problems within the broader context of international politics and relations. The existence of refugees exerts tremendous pressures on host countries and can influence foreign policy as well as exacerbate inter and intra-state conflicts. An increased understanding of the destabilizing potential of refugee movements is necessary for a comprehensive study of security.

Estimates of refugee totals, however, only reflect those migrants who are currently recognized. Refugees are officially defined as those who decide to seek asylum out of fear of political, racial, or religious persecution, or those who leave their homes because of war or civil strife (Jacobson, 1988). It is argued, however, that such a definition excludes a growing number of people, and that the traditional definition is proving to be too narrow. Using the political interpretation of refugees, those people displaced by violence or warfare but not singled out for individual persecution are ignored, and economic refugees are also excluded. This fact is leading to widespread criticism of the type of definition used by most official agencies, including the United Nations (Ferris, 1985).

The role of environmental degradation is now regarded as being of central importance in the issue of refugee movements and global security. Overlooked in traditional definitions is perhaps the fastest growing class of displaced people - those now commonly referred to as "environmental refugees". In a U.N. study of this problem, El-Hinnawi (1985) defines environmental refugees as:

> those people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption that jeopardized their existence and/or seriously affected the quality of their life. p. 4.

It has been estimated that as many as 10 million people in the world today are fleeing not from political problems, but from the land itself (McInnes, 1990). The number of environmental refugees rivals that of officially recognized refugees and, if present trends continue, by the middle of the next century the number of environmental refugees is likely to exceed the number of refugees from all other causes by a factor of six (Jacobson, 1988; McInnes, 1990). Because environmental refugees are not recognized by the United Nations and the issue is poorly

understood by the international community, those fleeing environmental decline are not given protection or support, and a lack of awareness exacerbates their problems.

The effect of this growing number of displaced people may be quite devastating. Simply the concept of tens of millions of persons permanently displaced from their homes is a frightening prospect, one without precedent and likely to rival most past and current wars in its impact on humanity (Jacobson, 1988). Environmental degradation can send large numbers of people across national borders into other countries, often creating a great deal of tension by doing so (Timberlake and Tinker, 1984, Westing, 1986). In the host countries, the infrastructure and services are often below standard and can hardly meet the needs of indigenous people who use them. An influx of refugees into such areas exerts more pressure on services and can create conflict with regular users (El-Hinnawi, 1985). Additionally, most refugees find themselves in slums and squatter settlements where they are deprived access to basic facilities, forced to use open water for washing and cleaning, and live in makeshift shelters where crowding and accumulating wastes result in disease. In these conditions, there are conflicts among the residents of the settlements, a great number of riots, high levels of crime and drug addiction, and mistrust between the refugees and the original population (El-Hinnawi, 1985). Environmental refugees, then, can cause domestic strife and considerable friction when they cross international borders.

In addition to those people who are forced to leave their home country are those who are forced by environmental degradation to relocate within their own borders. Throughout the world, there is a migration of subsistence farmers to cities where there are few opportunities and where the infrastructure is already overextended (Timberlake and Tinker, 1985). Like those

forced to cross borders, the desperate populations moving within their own countries are prone to engage in crime and civil disorder, affecting the political stability of cities (El-Hinnawi, 1985). These refugees also come into conflict with people who already live in the slum areas, leading to further conflict. At the same time, this migration also affects development in rural areas by decreasing available labour, making it more difficult for the government to feed its people and perhaps resulting in food riots (Jacobson, 1988). Again, however, if people do not cross an international border, they do not technically qualify as refugees under present definitions, and are not eligible for assistance and protection, instead being subject to inconsistent and slow responses (Clark, 1989). These so called "internal refugees" face several problems, but the primary one is that their government usually does not have the resources necessary to provide adequate relief, and they fall outside of the mandate of international organizations existing to aid displaced people.

According to the U.S. Committee for Refugees, there are approximately 2 million recognized refugees in the Middle East, with an additional 500,000 or more people internally displaced (Rogge, 1987). The potential for increased tensions in the region as a result of environmental refugees, then, is quite substantial. Urbanization, caused by desertification and land degradation in the countryside, is also a problem throughout the region. With water scarcity increasing and food production declining, Middle Eastern governments are not able to support the growing populations in the cities, resulting in general unrest.

Several violent confrontations in the recent past have been associated with environmental refugees. In Ethiopia in 1984, drought drove Afar tribesmen from their traditional pasturelands into the highlands, already occupied by settled farmers and also suffering from the drought.

Tensions mounted between the nomads and the indigenous farmers, who viewed the newcomers as "invaders" who deprived them of grazing land and accelerated deterioration of the land (Timberlake and Tinker, 1985). A second example can be taken from Sudan, where by the end of 1984 more than one million people were affected by drought; many fled across the border searching for water and pastures and were eventually put into refugee camps requiring a great deal of assistance and leading to unrest (El-Hinnawi, 1985).

As governments attempt to deal with the problems of diminishing resources, development projects may increase the problem of environmental refugees. In the case of the building of the Aswan High Dam in Egypt, the result was the displacement of nearly 100,000 Nubians who had lived on the banks of the Nile since ancient times. The Nubians, moved to refugee camps, were generally unhappy and dissatisfied with their situation as health conditions deteriorated (Fahim, 1981). Timberlake and Tinker (1984) point out that present land pressures exacerbate traditional rivalries, and the use of modern weapons instead of spears and arrows now makes it more deadly. Conflicts between indigenous peoples and forced migrants could represent a major security concern in the future to the region, but in the absence of official recognition of environmental refugees it is doubtful little interest will be paid to this problem.

VI. CONCLUSIONS

In summarizing the material that has been presented thus far, four questions are relevant. First, have there been environment/resource conflicts in the past in the Middle East that have posed a threat to the region and to international forces that participate there? Second, if so, are these conflicts over resource use likely to continue in the future, at levels where they impose a security threat? Third, are there other environmental factors that may exacerbate this situation? And fourth, is climate warming one of these factors?

The answer to the first question is, undeniably, yes. Two examples that are discussed extensively in the text are mentioned below.

1. **1967 War and the Security Zone**: Naff and Matson (1984) have documented a dozen water-related ceasefire violations in the Jordan River System between 1951 and 1967. Many authors have speculated that increased access to replenishable water supplies and increased control over existing supplies were major factors in Israel's involvement in the 1967 War. Israel's victory added almost 50% to its existing fresh water reserves and gave the country almost complete control over the major replenishment area for its underground reserves (the West Bank) and riparian rights over upstream tributaries to the Jordan. This was at a time when Israel was desperately seeking solutions to its demand for fresh water, which equalled its supply. The subsequent establishment of an Israeli controlled security zone into southern Lebanon now places it within easy reach of the Litani River; Israeli interests in diverting the Litani into the Jordan River system have long been public.

2. **New Irrigation Projects**: Egyptian government officials believe that Israeli water engineers have been working in Ethiopia and Uganda, planning irrigation projects that could reduce the amount of Nile River water reaching Egypt.

It is apparent that water related conflicts have existed in the Middle East for some time; even in the absence of economic, demographic and other environmental changes it would appear

that these conflicts will continue. The changes that are taking place within the region, however, are quite sobering relative to the ability of the resource base to accommodate these changes. The seven riparian states in the three watersheds exhibit some of the highest rates of population growth in the world, and, with water demand nearing available supply in some regions, it seems unlikely that these countries can accommodate such growth without major restructuring or, in the absence of this, armed conflict. By the middle of the next century, the population of Egypt will be well over 100 million, and growth rates throughout the region imply that population will be doubling every 25 - 35 years. A major emphasis in these countries is self-sufficiency in agriculture. But agriculture is very water intensive, and expanded output in this sector will require substantial water inputs. This problem must be coupled with the spatial movement and distribution of the population; expanded settlements reduce discharge to rivers (e.g., the Golan Heights) and replenishment of aquifers (e.g., the West Bank); rural-urban migration to the urban fringe often converts prime agricultural land to residential uses, resulting in more marginal land being used for agriculture, a much more water intensive operation (e.g., Egypt); and growing populations demand more irrigation water, taken by upstream riparian states which reduces available flows downstream (e.g., Sudan and Ethiopia). These are examples of changes that are having considerable impacts on the resource base of the region. In many cases, significant improvements could be made in the efficiency of water use including the use of wastewater, but often these are very expensive options.

The two countries most concerned over the present water crisis are Israel and Jordan. In both countries water demand is equal to, or exceeds, supply, and tension between the two over the Jordan River creates an additional source of potential conflict. With attempts to expand

agricultural output, industrial growth and considerable population growth, both countries are badly in need of alternative supplies. Israel has even begun shipping water from Turkey in tankers as a short term, stop-gap measure. Over the next decade, it appears that Israel must complement its fresh water supplies by one of three methods. The country could enter into a shared agreement over water use with other countries, such as Lebanon. Given the past record in water sharing agreements and the general level of tension in the region, this is highly unlikely. A second option would be to restructure the economy, converting to less water-intensive processes, which means moving from an agriculturally based system to industry and manufacturing. Last, militarization of the water conflict could by viewed as the most viable option, with the possible forced diversion of the Litani River being justified on the basis of the river being part of the larger Jordan River watershed (an argument that Israel has been making for many years). Although the costs of a war would be much higher than even costly reclamation and desalinization projects, it cannot be ruled out. It has been in vogue to comment that the next war in the Middle East will be over water, but there is much substance behind this argument. The militarization of water conflicts in the region has occurred in the past and likely will continue in the future. It is concluded that Israel has little choice except to restructure the country's economy; foreclosing this option would leave only one viable alternative, that of acquisition of water by military means.

What role might climate warming play in the exacerbation of this conflict in the future? It appears that the warmer temperatures and moderately less rainfall projected by the climate models will affect the supply of surface water and the replenishment of ground water supplies. Evaporation could decrease by 5 - 10% and soil moisture (which was not estimated, but would

have a considerable impact on the demand for irrigation water) could decline by a similar amount. These impacts on water supply, however, are expected to occur gradually over the next fifty to sixty years; with population growing at 2.5% annually, and industrial and agricultural output increasing as well, it appears that climate change will be a relatively minor factor in determining the role of environment and resources in conflict formation in the region in the near future. These other variables could so overwhelm the ability of the resource base to accommodate change that serious conflicts would result long before the effects of climate warming were noticed. On the other hand, climate warming <u>will</u> directly impact on existing water supplies, and the economic and demographic changes should be viewed in the context of broader environmental changes that will stress the region even more than at present. As Renner (1989) noted, it will "undermine the natural support system" on which the region depends. Given this, climate warming should be integrated with any further study of environment and security in the region, not as a major causal factor but certainly as an associative one, with the potential for making an already difficult situation even more dire. The importance of environment and resources to security in the Middle East cannot be denied and the relationship is deserved of more intensive research.

Acknowledgements:

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APPENDIX I

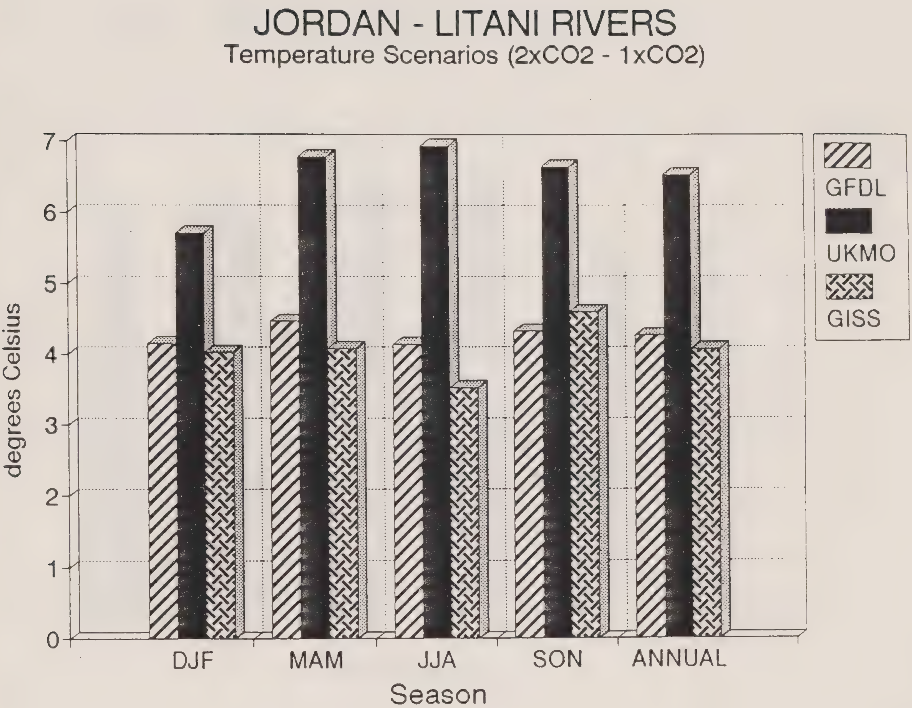

Figure A.1.1 Temperature scenarios, Jordan-Litani Rivers, by season.

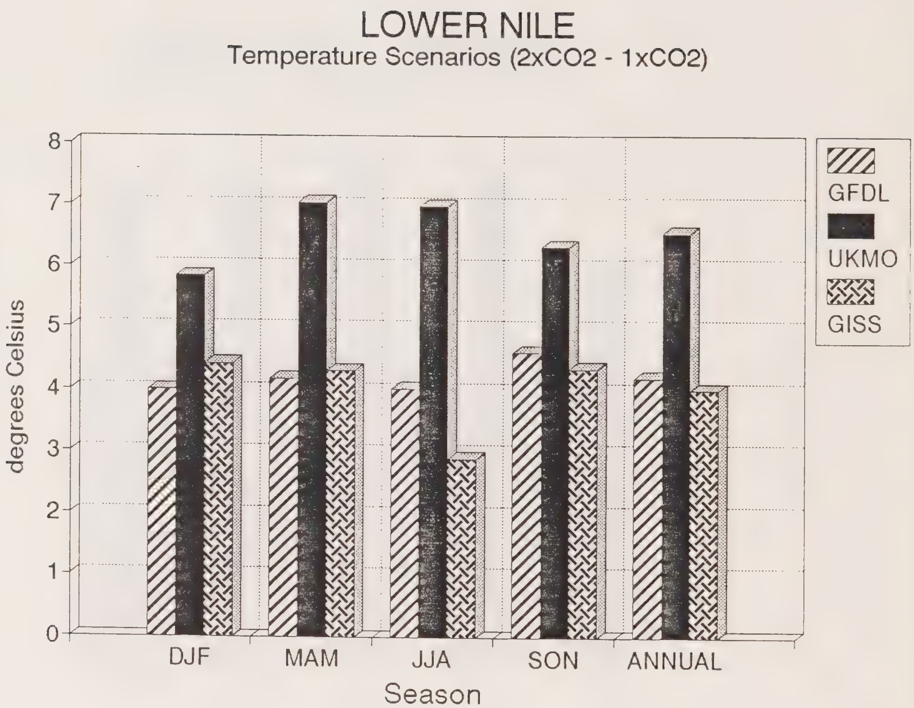

Figure A.1.2 Temperature scenarios, lower Nile, by season.

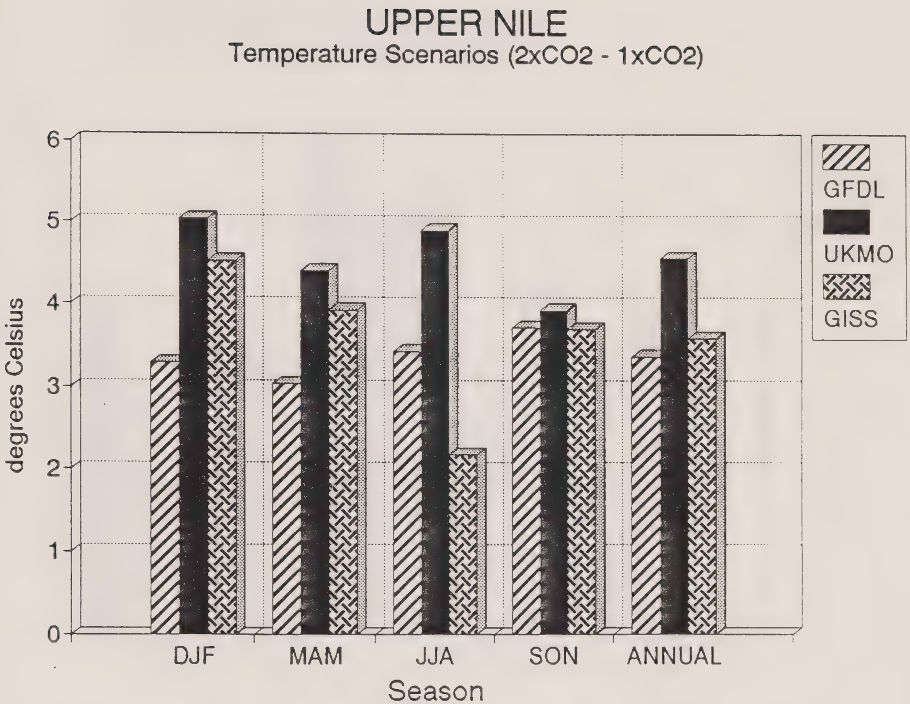

Figure A.1.3 Temperature scenarios, upper Nile, by season.

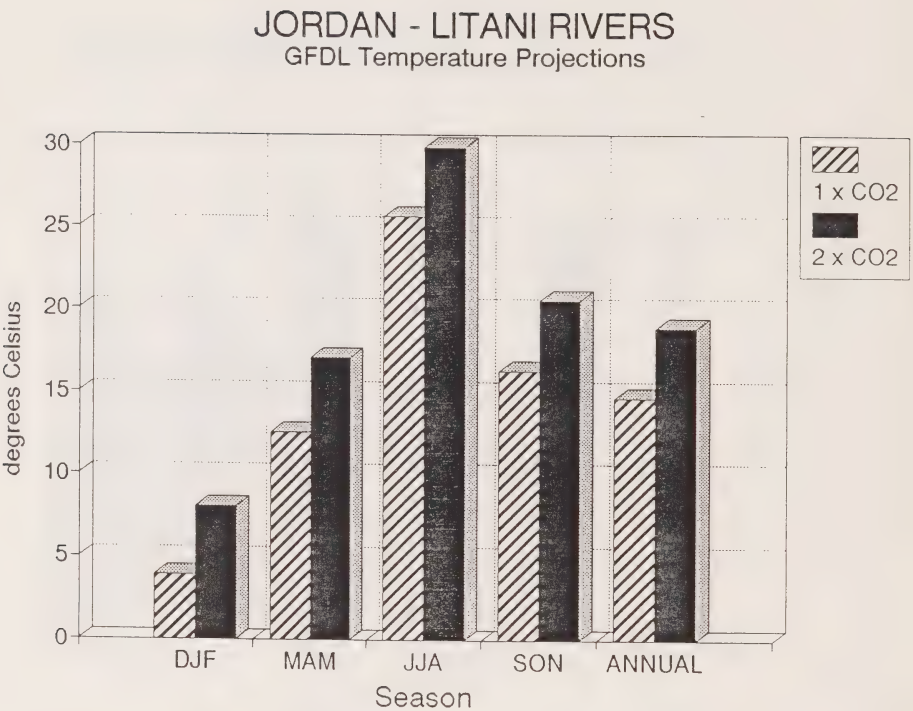

Figure A.1.4 GFDL temperature projections, Jordan-Litani Rivers, by season.

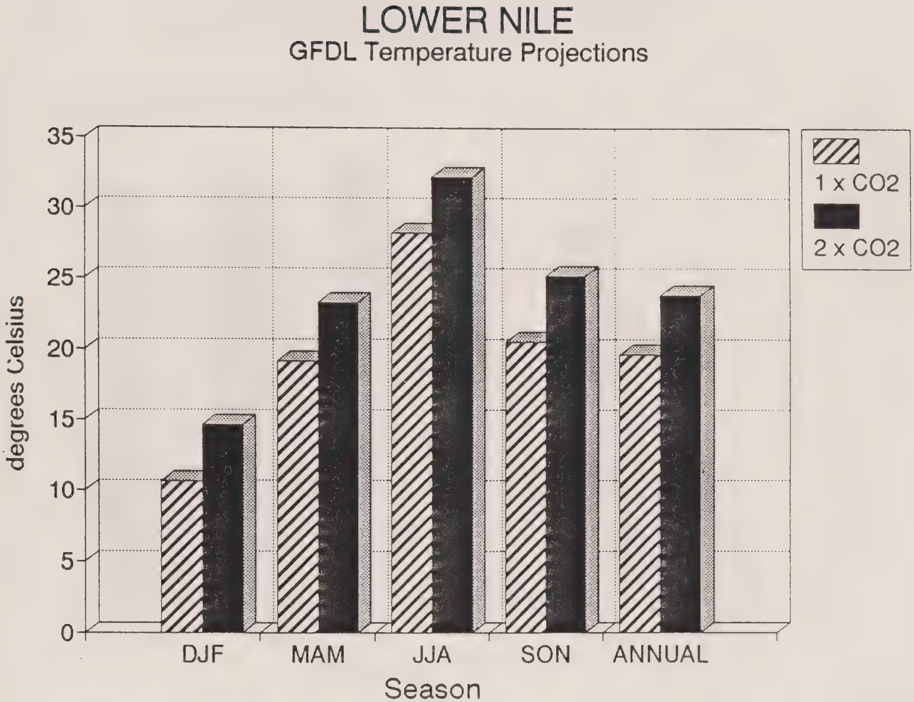

Figure A.1.5 GFDL temperature projections, lower Nile, by season.

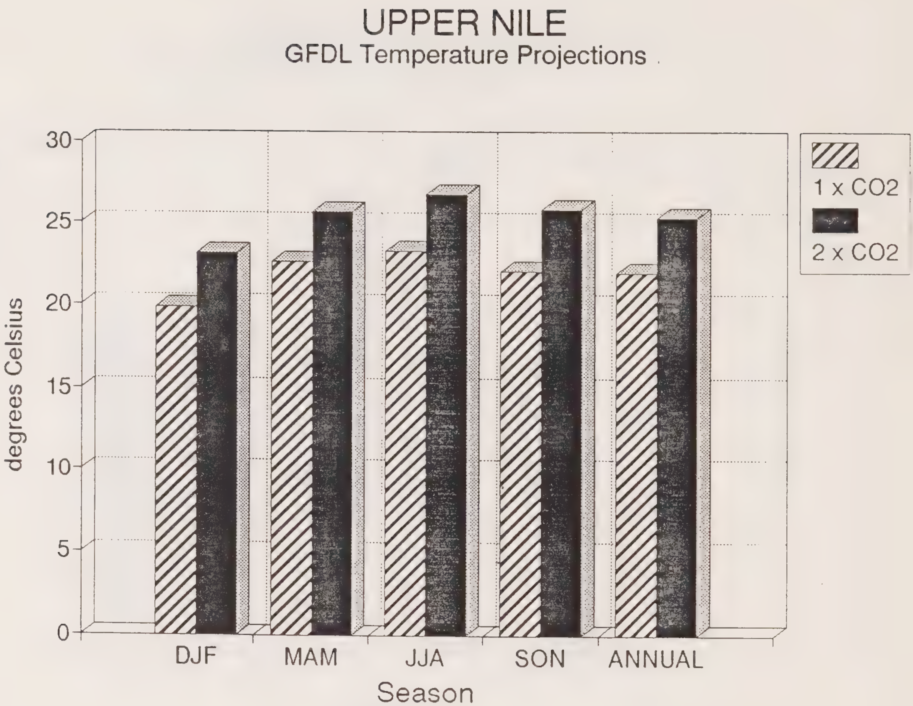

Figure A.1.6 GFDL temperature projections, upper Nile, by season.

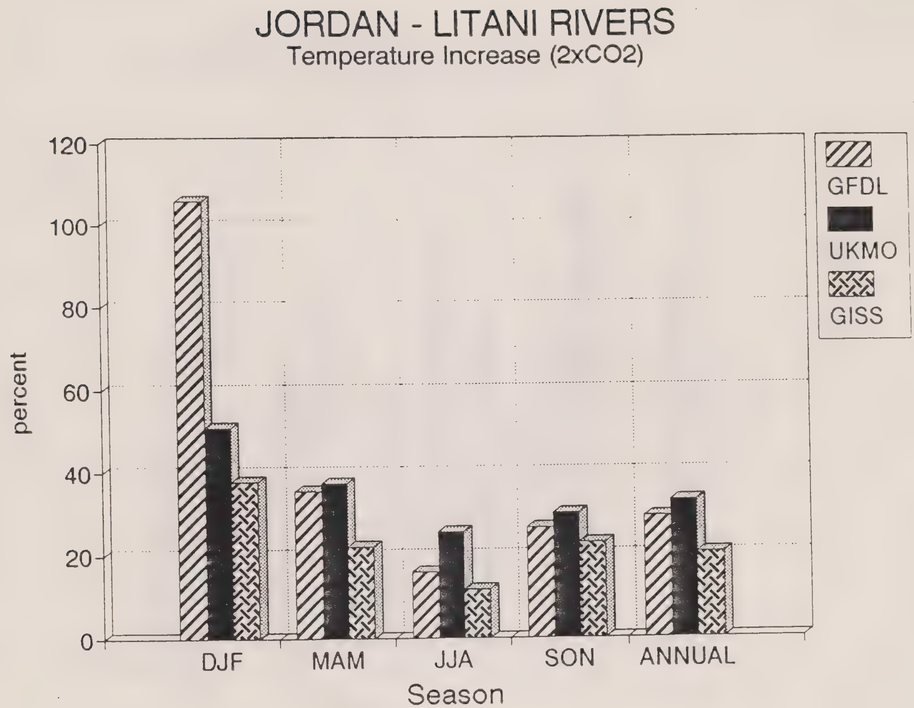

Figure A.1.7 Percent increase in temperature under 2xCO2, Jordan-Liatani Rivers.

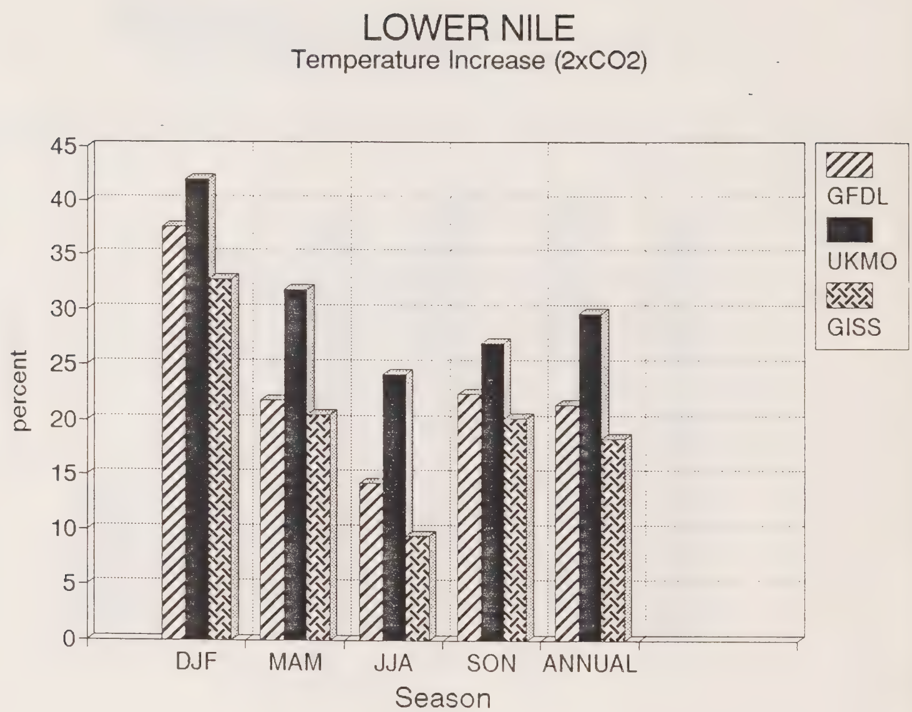

Figure A.1.8 Percent increase in temperature under 2xCO2, lower Nile.

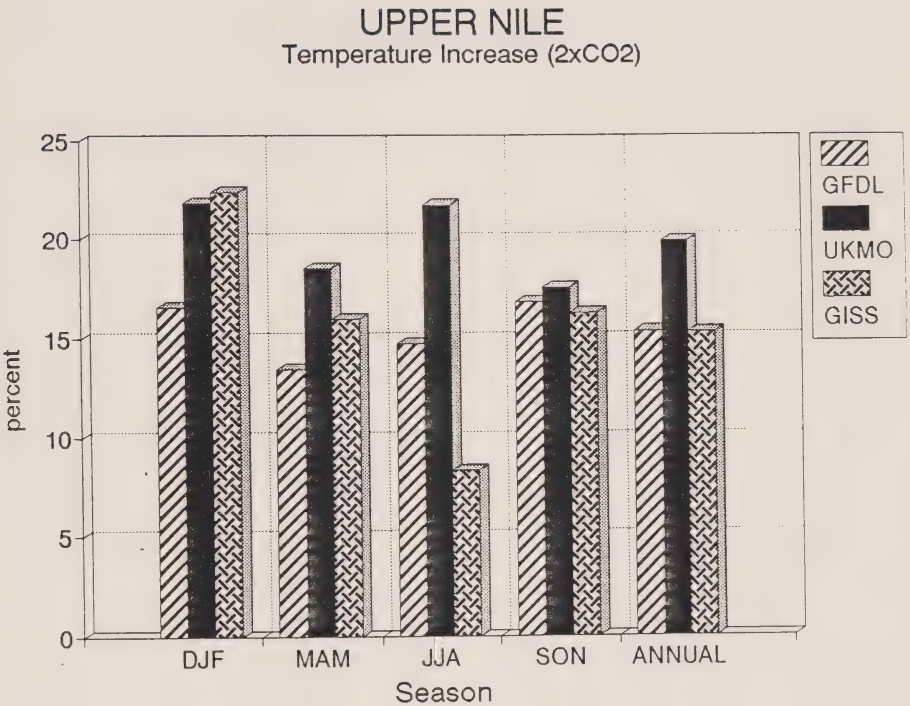

Figure A.1.9 Percent increase in temperature under 2xCO2, upper Nile.

APPENDIX II

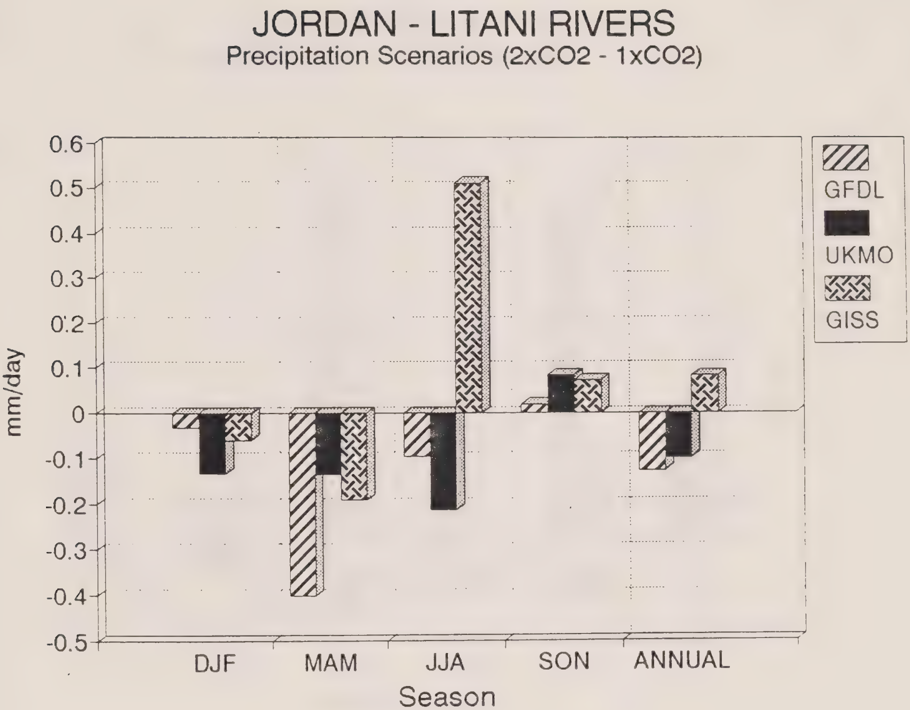

Figure A.2.1 Precipitation scenarios, Jordan-Litani, by season.

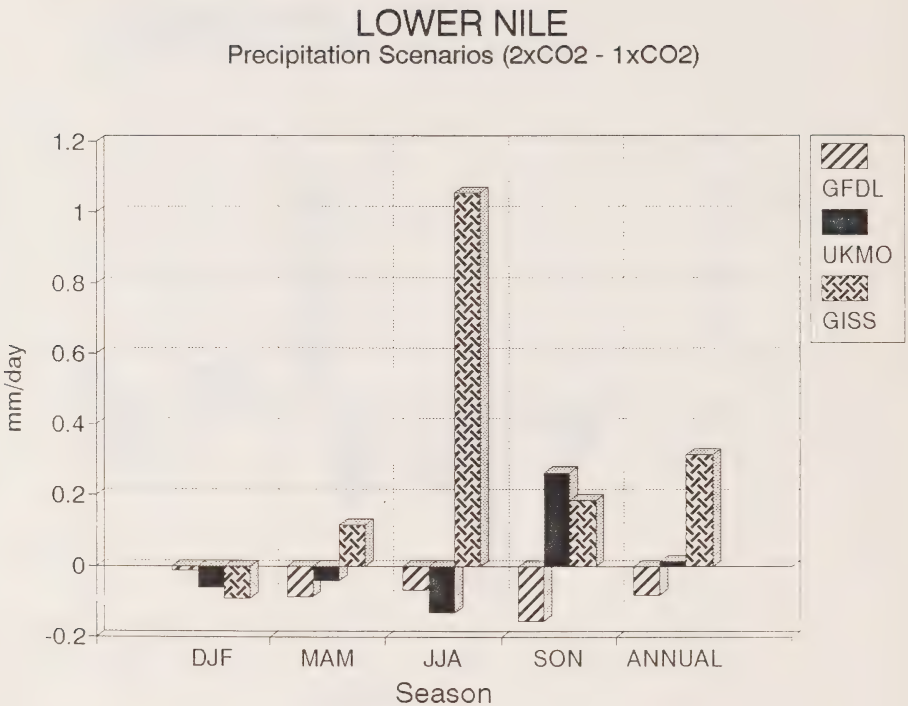

Figure A.2.2 Precipitation scenarios, lower Nile, by season.

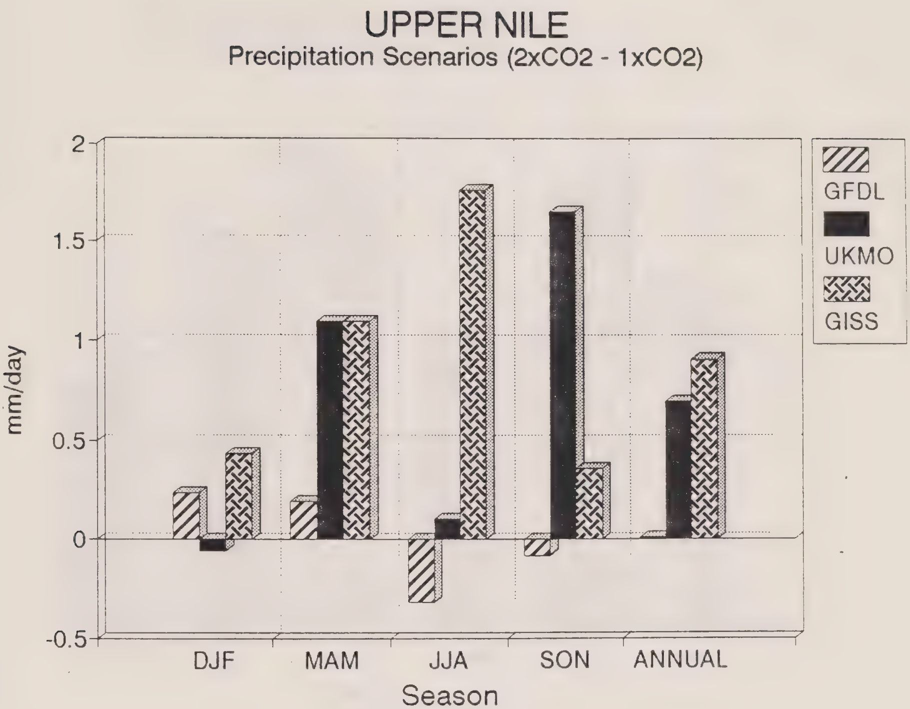

Figure A.2.3 Precipitation scenarios, upper Nile, by season.

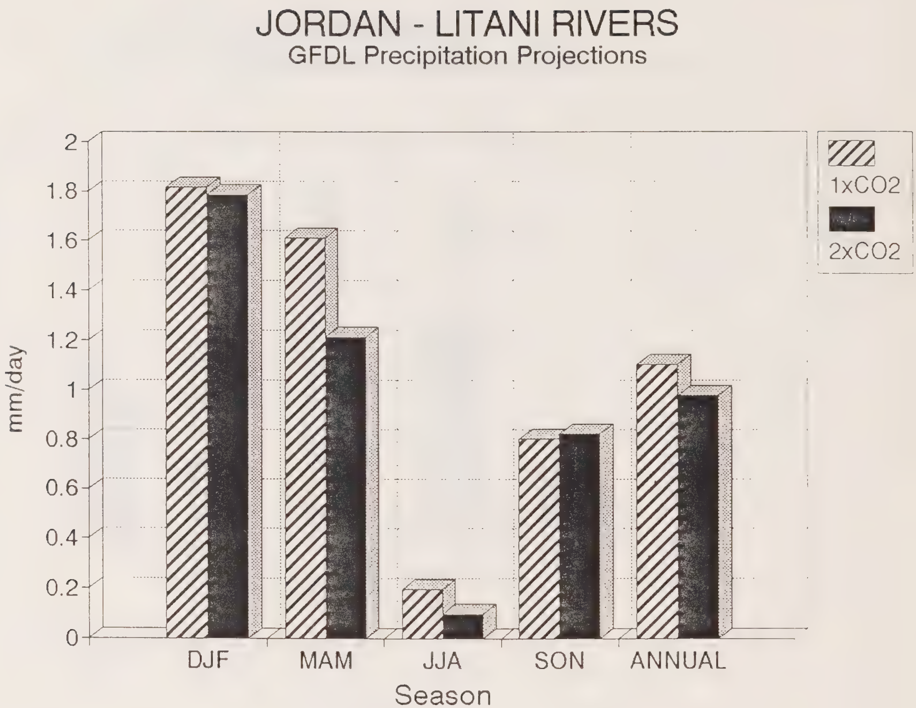

Figure A.2.4 GFDL precipitation projections, Jordan-Litani Rivers, by season.

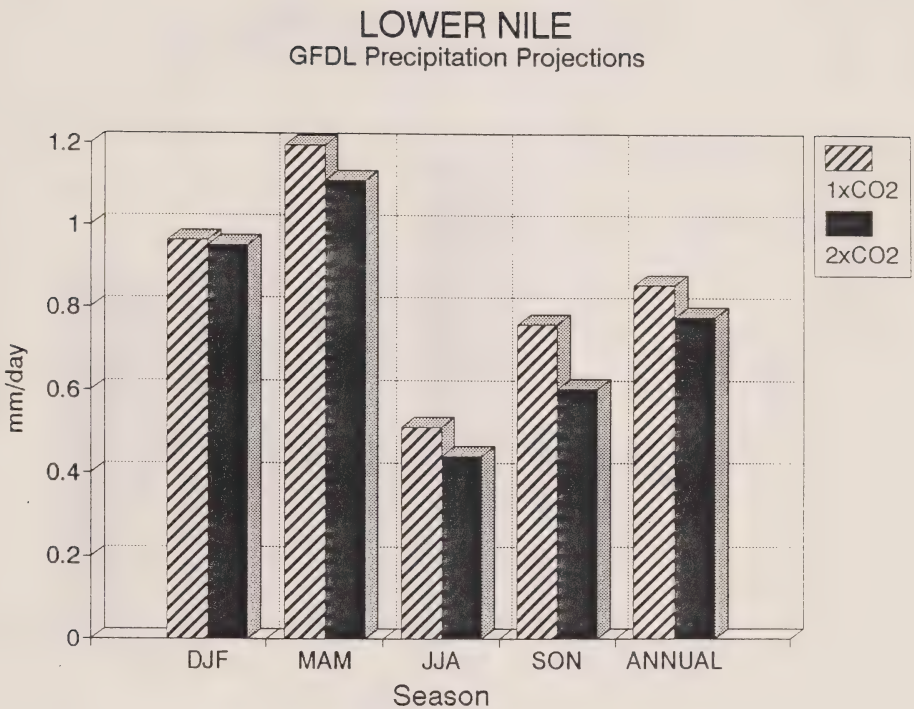

Figure A.2.5 GFDL precipitation projections, lower Nile, by season.

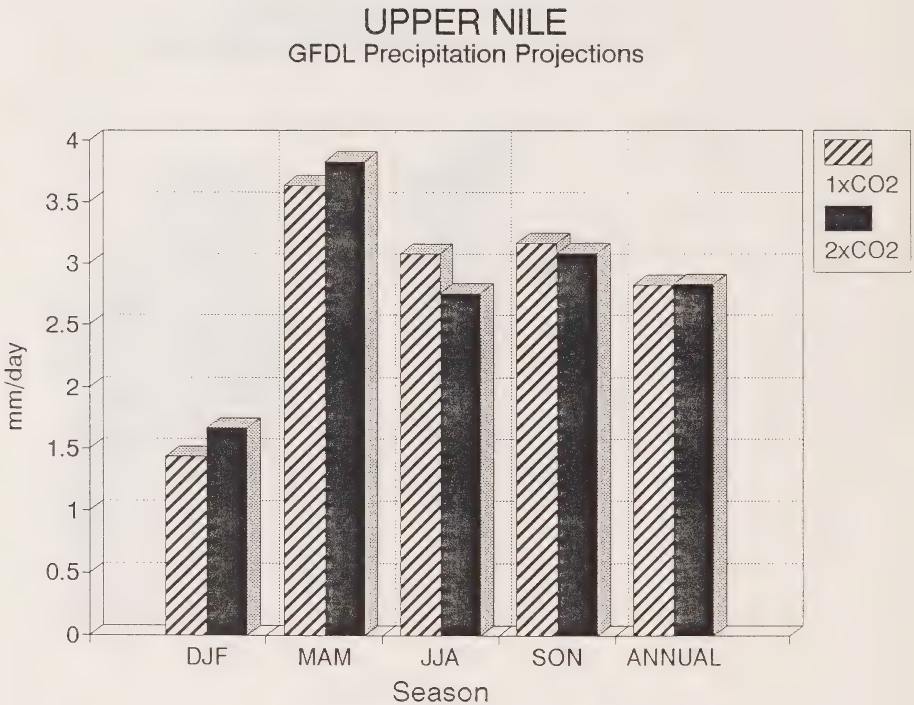

Figure A.2.6 GFDL precipitation projections, upper Nile, by season.

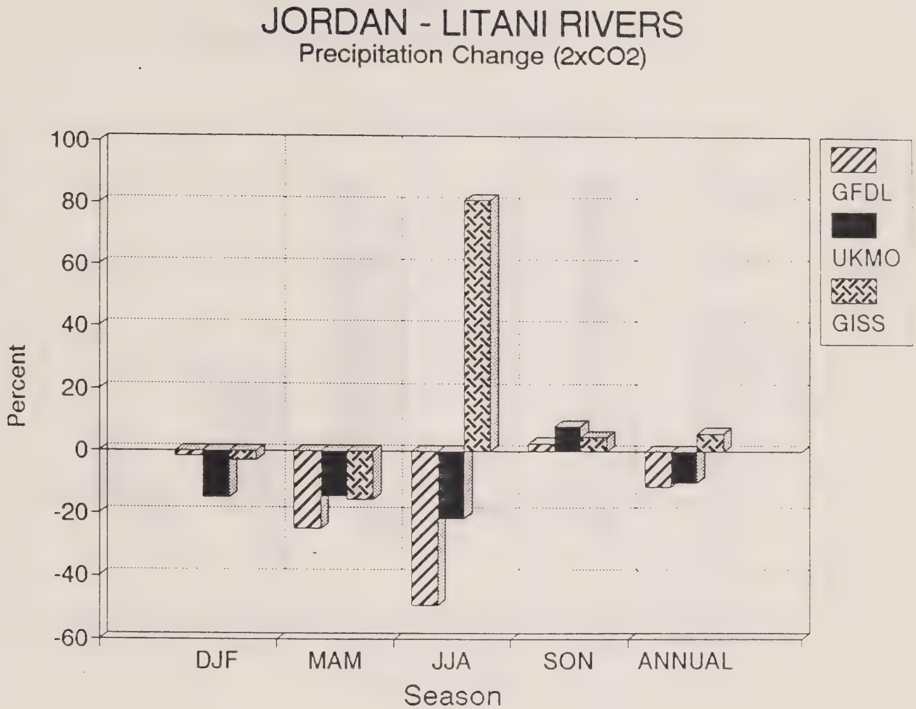

Figure A.2.7 Percent increase in precipitation under 2xCO2, Jordan-Litani Rivers.

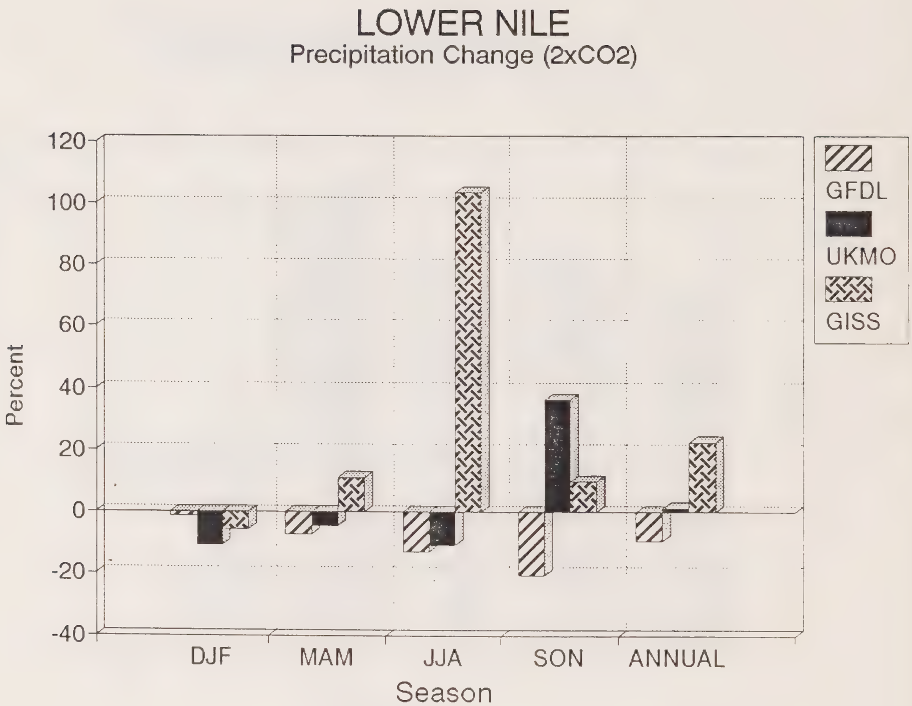

Figure A.2.8 Percent increase in precipitation under 2xCO2, lower Nile.

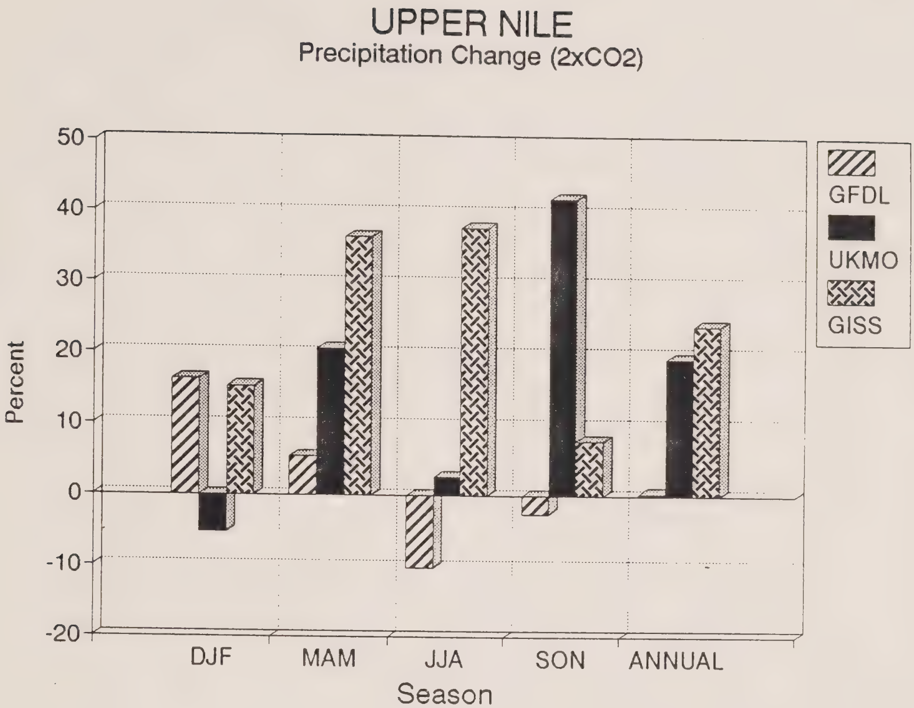

Figure A.2.9 Percent increase in precipitation under 2xCO2, upper Nile.

APPENDIX III

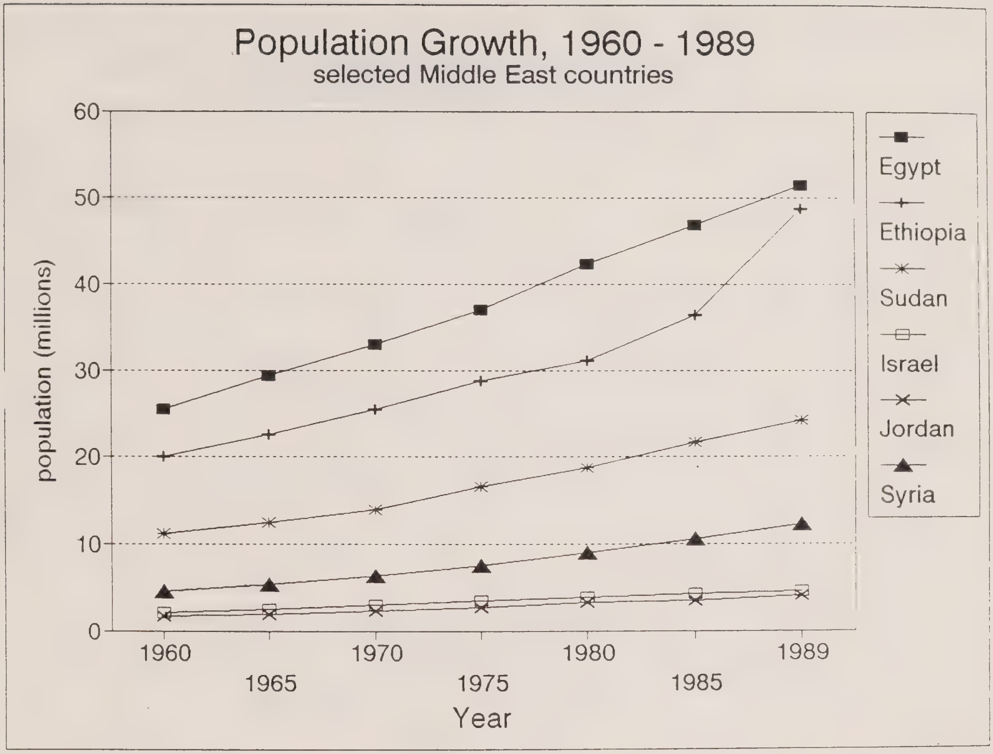

Figure A.3.1 Population growth, 1960 - 1989, selected Middle East countries.

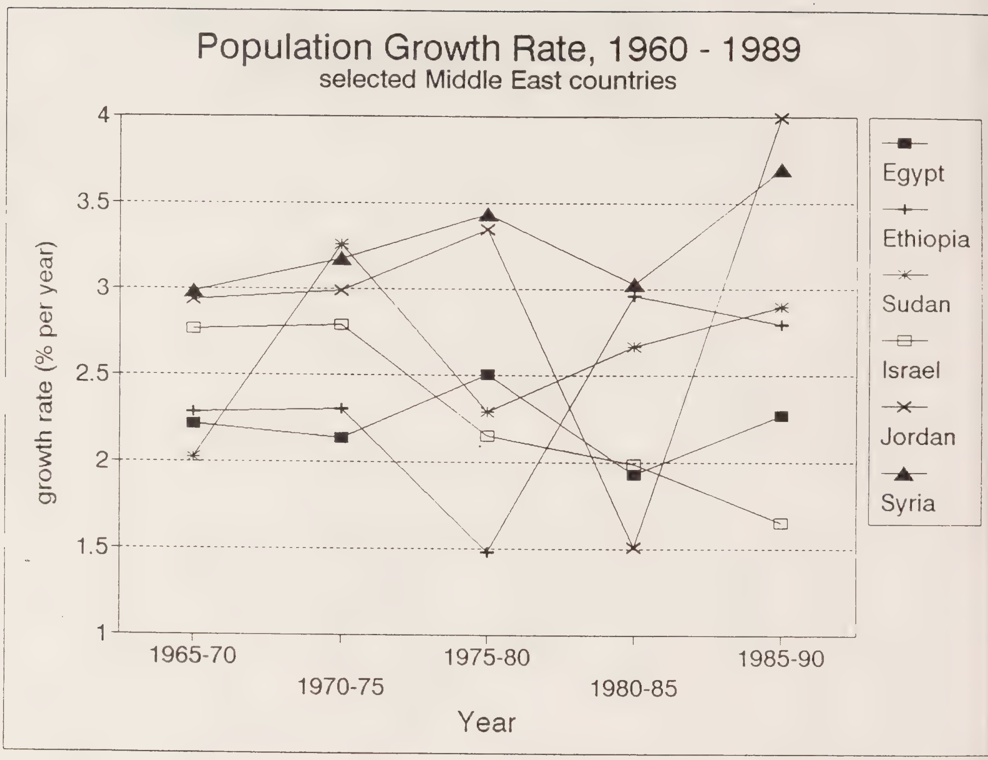

Figure A.3.2 Population growth rate, 1960 - 1989, selected Middle East countries.

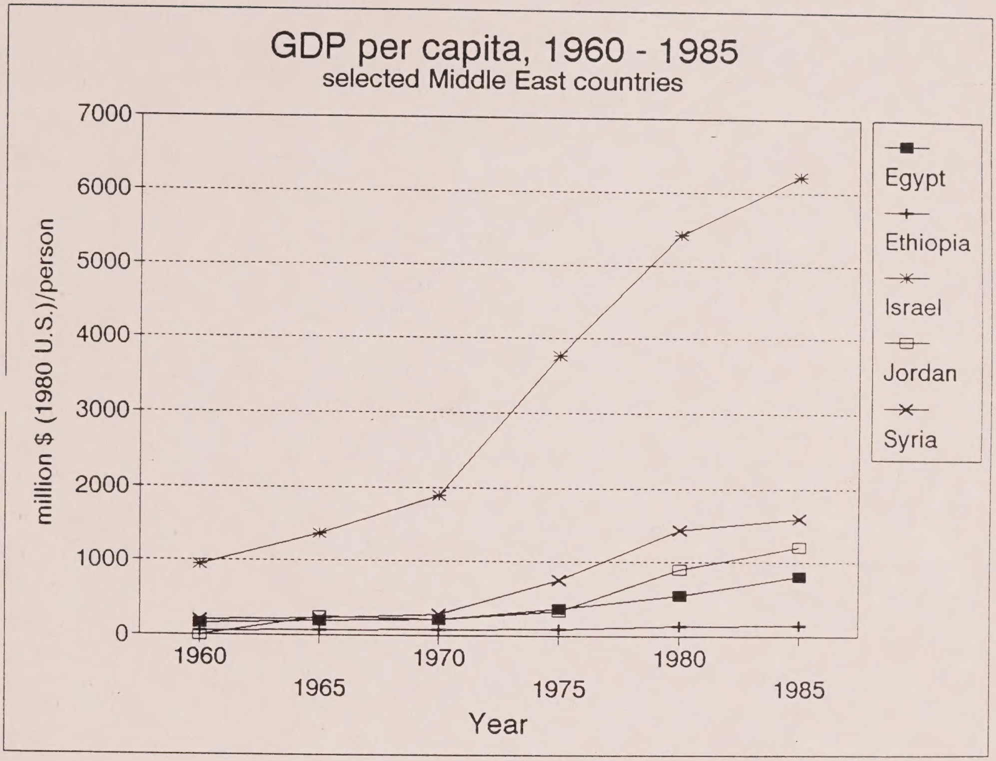

Figure A.3.3 Per capita gross domestic product, 1960 - 1985, selected Middle East countries.